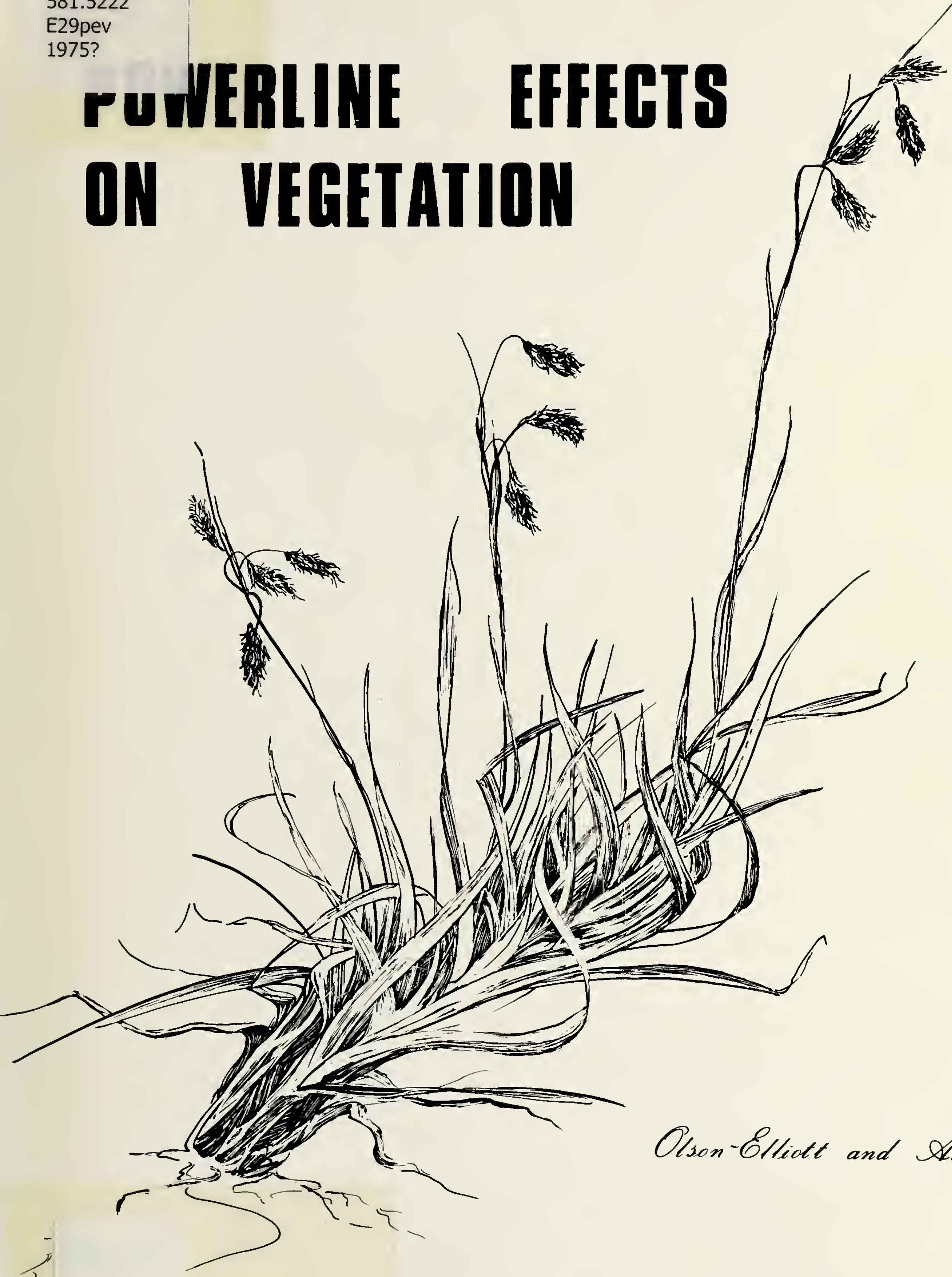
POWERLINE EFFECTS ON VEGETATION



Olson-Elliott and Associates

POWERLINE EFFECTS ON VEGETATION

(With Special Reference to Southwestern Montana)

A Literature Review and Rationale for Evaluating
Impact of Transmission Line and Access Road Construction and
Maintenance on Vegetative Communities

For: The Energy Planning Division
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I. INTRODUCTION

This report contains a review of literature relating to the effects of transmission lines and their construction on vegetation in Montana, and a description of the rationale used in determining the impact of transmission lines on vegetation. It includes an explanation of the mapping units used in describing the vegetation in the Dillon-Clyde Park study area, and an analysis of the possible effects of transmission line construction on the vegetation types in the study area. The report is intended to provide a basis for estimating the impact of transmission line construction and maintenance on plant communities in this area.

II. LITERATURE REVIEW

A. Introduction

This review was conducted during April, May, and June of 1975; the main emphasis is on plant communities of the Dillon-Clyde Park study area (figure 1), but other studies that bear on effects of power lines on vegetation are included.

The review is divided into two sections. The first concerns the general effects of transmission line construction on vegetative communities. The second deals with vegetative communities within the study area and summarizes research or information relating directly to them. The information uncovered in this review was used in developing the rationale for analyzing the impact of transmission lines on plant communities in the study area (see Section III).

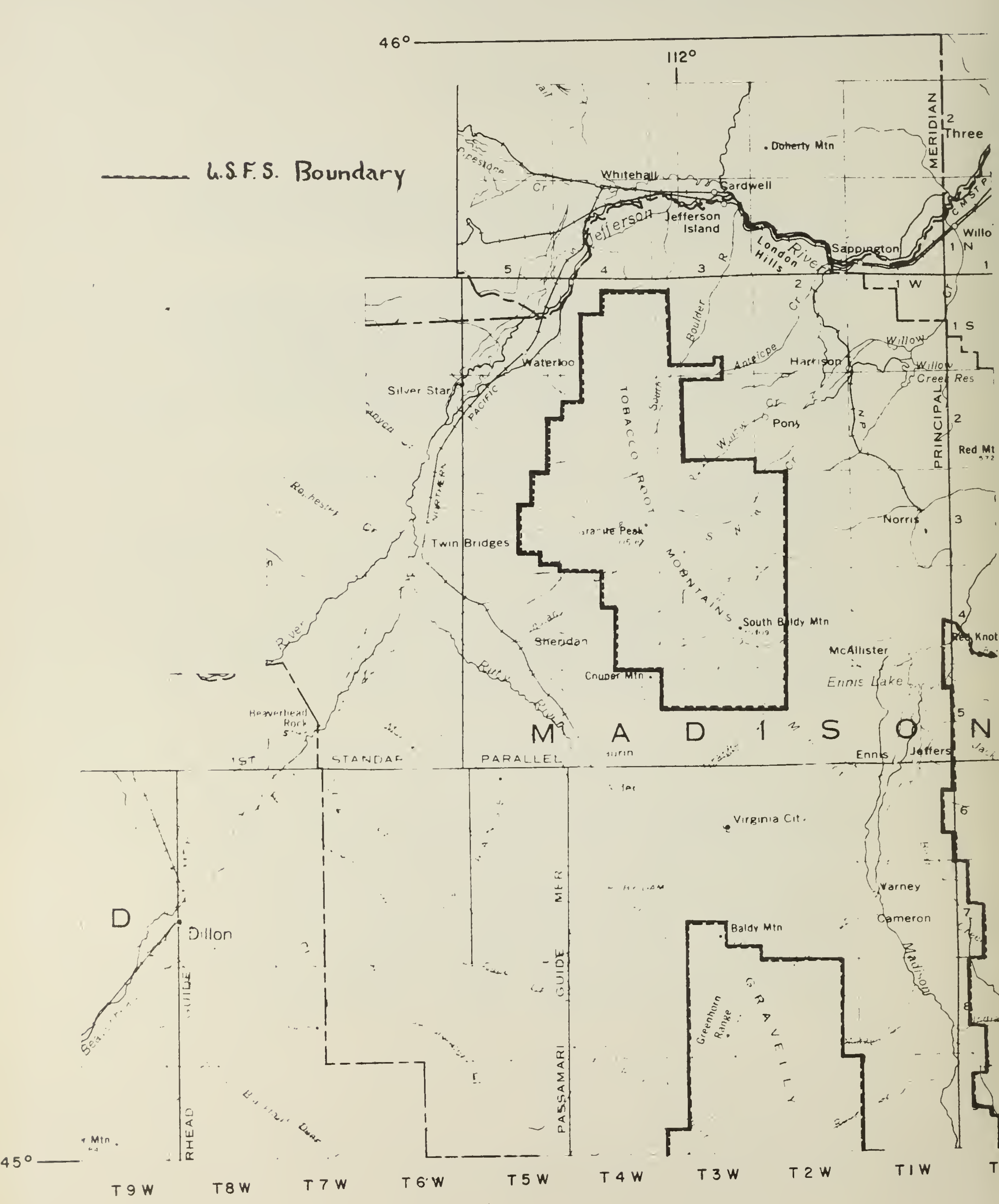
B. General Effects of Power Line Construction and Maintenance on Vegetative Communities.

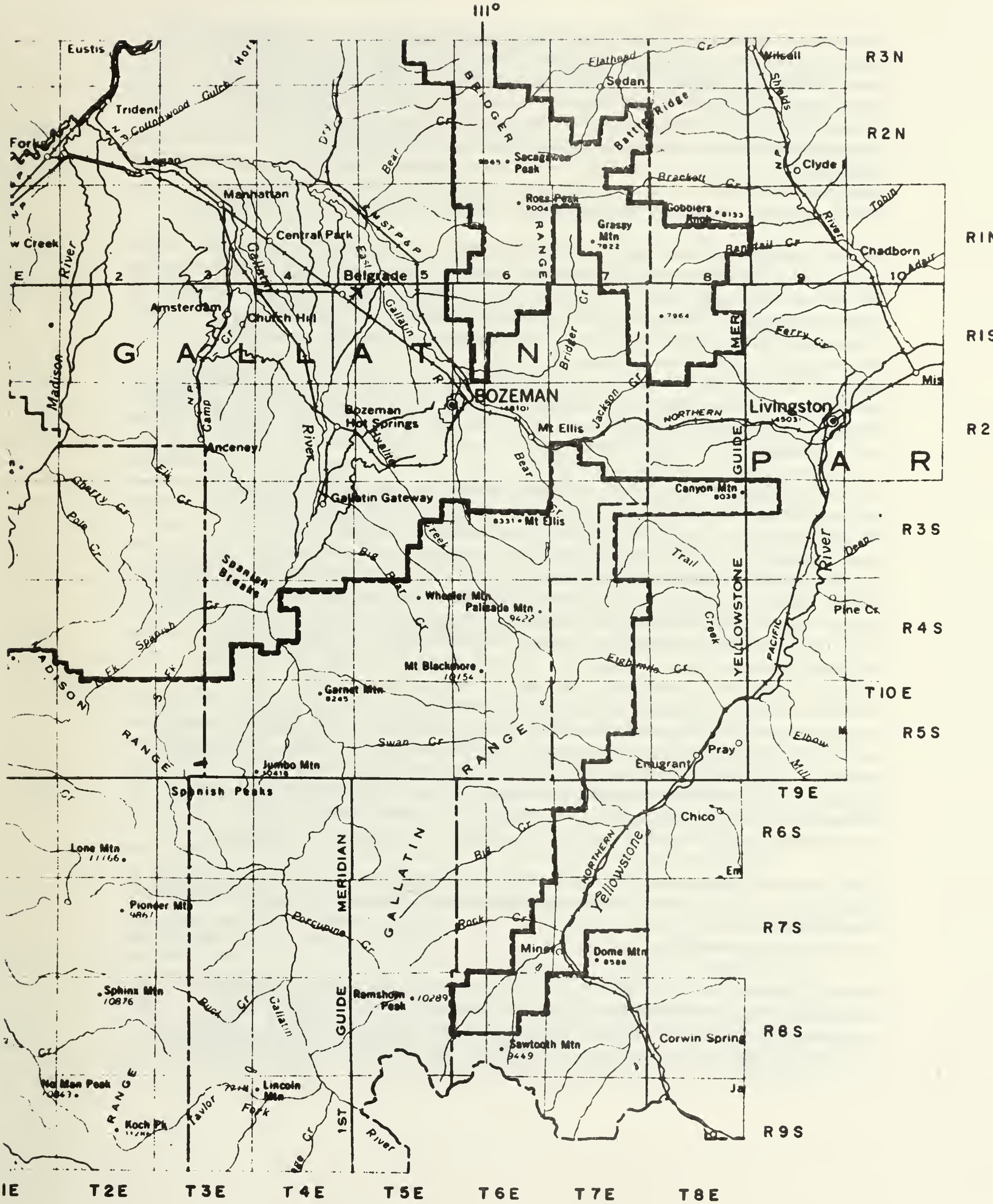
1. Effects of air pollutants associated with power line development.

The air pollutants associated with power lines are generally considered to be oxidants produced by the corona discharge. Ozone is the most likely to occur in measurable quantities. The impacts of ozone from transmission lines have been reviewed by Goodland (1973), Kitchings _et al_. (1974), and the Energy Planning Division of the Montana Department of Natural Resources (1974).

The effects of ozone on plants have been intensively studied. A recent bibliography concerning the effects of air pollutants on vegetation is available on microfische (Bogle, 1975). It lists over 200 references on the effects of ozone on plants. Ozone effects on vegetation have been reviewed by Rich (1964) and Darley and Middleton (1966). Although these authors described ozone damage to plants as a widespread phenomenon, they did not attribute damage directly to power lines as the source of ozone. Ozone damage to plants was also noted by Hindawi (1970); Treshow (1965) described how vegetation damage can be used as a field assay technique to determine the presence of ozone and other pollutants. Murr (1964) described the modes of action of ozone produced by electrostatic charges on plant tissues.

FIGURE 1. DILLON-CLYDE PARK TRANSMISSION LINE STUDY AREA




111°
Eustis
Trident
Cottonwood Gulch
Logan
Manhattan
Central Park
Belgrade
Amsterdam
Church Hill
GALLATIN
BOZEMAN
Bozeman Hot Springs
Anceney
Gallatin Gateway
Spanish Breaks
BRIDGER
RANGE
Sedan
Flathead
Battle Ridge
Sacagawea Peak
Ross Peak
Grassy Mtn
Gobblers Knob
Brackett Cr
Bangtail Cr
Bridger Cr
Jackson Cr
Mt Ellis
Wheeler Mtn
Palisade Mtn
Mt Blackmore
Garnet Mtn
Jumbo Mtn
Swan Cr
Spanish Peaks
Wilsall
Shields
Clyde
Chadborn
Tobin
Ferry Cr
Livingston
NORTHERN
PACIFIC
PAR
Canyon Mtn
Trail Creek
Eightmile Cr
YELLOWSTONE
GUIDE
MER
Pine Cr
Pray
Emigrant
Elbow
Mill
Chico
Yellowstone
Miner
Dome Mtn
Corwin Spring
Sawtooth Mtn
Ramshorn Peak
Porcupine Cr
Buck Cr
Rock Cr
GALLATIN
RANGE
GUIDE MERIDIAN
1ST
Lone Mtn
Pioneer Mtn
Sphinx Mtn
No Man Peak
Koch Pk
Lincoln Mtn
Taylor Fork
MADISON
RANGE
Madison River
Cherry Cr
Pole Cr
Elk Cr
Spanish Cr
R3N
R2N
R1N
R1S
R2S
R3S
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R6S
R7S
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Studies of the effects of ozone on vegetation native to southwestern Montana are quite limited. Miller et al. (1963, 1969) reported ozone injury to ponderosa pine (a rare species in the study area). Treshow and Stewart (1973) listed a large number of species that occur in the study area and their relative susceptibility to ozone concentrations as determined by fumigation studies. The U.S.D.A Forest Service (1973) listed species sensitive to air pollutants, including ozone. Many of these species occurred in the study area.

Recently many studies have been conducted to determine ozone production from transmission lines, particularly the 500 kV and above voltage types. Frydman et al. (1972) and Fern and Brabets (1974) conducted field studies associated with 765 (kV) lines and were unable to detect any measurable amount of ozone. Roach et al. (1973) and Scherer et al. (1972) conducted laboratory studies to determine ozone production under a variety of environmental conditions and determined that the ground level concentrations of ozone produced by high voltage (>500 kV) transmission lines will probably be insignificant.

The environmental impacts of ozone have been discussed by the Montana State Department of Natural Resources Energy Planning Division (1974). Their discussions, however, appear to be contradictory. The discussion on vegetation (pp. 194-195) suggests that synergistic effects of ozone and SO_2 in the Anaconda, Butte, Helena, and Billings areas may have harmful effects on vegetation. In addition, it suggests that in mountain valleys with temperature inversions, ozone could change the composition of plant communities. However, in the discussion on air quality and transmission lines (pp. 203-206), the authors state: "... because studies to date do not indicate a significant impact of transmission lines on air quality, no attempt will be made to select transmission line corridors on the basis of ozone production rates." Further, this section of the report states that the singularly high measurements recorded by the Oak Ridge National Laboratory (1972) (from which the impact predictions in the vegetation section stem) do not represent a significant trend.

This latter prediction of minimal ozone impact is shared by Goodland (1973), but this author cautions that any increase in ozone concentrations in urban areas with high oxidant concentrations should be viewed critically.

Other effects on air quality, such as particulate concentrations caused during construction by slash burning or road dust, were reviewed in the literature. Although much information is available on effects of particulates from industrial or other sources, no

studies on effects of road dust were found. Effects of cement dust were investigated by Darley (1967, 1970). Certain dust types, such as cement dust, appear to have high toxicity to many plants. The harmful effects of dust on vegetation are apparently due to the chemical composition of the dust but information is insufficient to predict the effects of road dust on plants during transmission line construction.

2. Electrostatic and magnetic field effects on plants.

Until recently, the effects of electro-magnetic fields on living organisms have been neglected. Data on the effects of fields in the vicinity of transmission lines are nearly non-existent. Thus, much of the information here, while it deals with electro-magnetic fields, does not apply directly to transmission lines.

Electro-magnetic force fields (measured in Volts/meter) of the industrial frequency (50 hertz) are found near electrical transmission lines. In the case of high voltage lines (400-500 kV), the area near the lines may have an electrical field of several thousand V/m (Pressman, 1970). Murr (1965a, b; 1966) investigated the effects of electrostatic fields on corn, beans and sorghum growth. He found no apparent effect on seedling growth until a field of 100 kV/m dynamic potential gradient of direct current was reached. This is far in excess of that which occurs in the vicinity of transmission lines. According to Murr (1964), damage to plant cells at high dynamic potential gradients (greater than 100 kV/m) is apparently related to ozone production. Dynamic potential gradients of this magnitude may be reached during electrical storms (Murr, 1966).

Electrical phenomena and effects of lower level magnetic fields have been studied and reviewed (Audus, 1960; Scott, 1962; Barnothy, 1969; Marha *et al*., 1971). Plants appear to respond to low levels of magnetism and electrical fields, but there is no indication that these effects may be detrimental. Zhurbitskty (1972) found that plant growth in electrical fields of 180 V/m was greater than in a zero potential control. Gardner *et al*. (no date) studied the effects of low (10 V/m) electric fields on plants and soil microorganisms. Their results also indicated that growth may increase in an electrical field.

The Bonneville Power Administration has compiled a bibliography of current research on the effects of electric fields on organisms. The projects and addresses are included in the Appendix to this report. In addition, a bibliography on this subject is in preparation and will soon be available from the Electric Power Research Institute (available from Carole Poole, EPRI; Report No. EPRI-RP. 129; P.O. Box 10412; 3412 Hillview Avenue; Palo Alto, Ca. 94303).

3. <u>Survey of information concerning the management of vegetation on transmission line right-of-ways and general effects of disturbance</u>.

The establishment of vegetation in transmission line right-of-ways and the maintenance of a desirable vegetative cover has received much study in the eastern United States. Much of the available information also applies to roadside vegetation management. Frank Egler (1953a, b; 1957; 1958; 1973; 1974) is one of the leading researchers on ecologically sound management of right-of-ways. Right-of-way management usually involves establishing vegetation that resists invasion by trees or tall shrubs (Dohrenwend, 1973; Zuch, 1973; Richards, 1973; Goodland, 1973; Pound and Egler, 1953; Arner, 1951, 1966; Gysel, 1962; Niering, 1958; Bramble and Byrnes, 1967, 1972; Wagner, 1971; B.P.A., 1965). In general, a stable low shrub community appears to be most desirable and most able to maintain itself and prevent invasion of tree species. Richards (1973) and Arner (1966), however, suggest that grassland or meadow communities may be easier to establish and maintain. The suitability of each type (i.e., grassland or shrubland) depends on soil, climate, slope, etc. within the right-of-way.

Right-of-way maintenance (also called noxious weed control in many areas of Montana) by means of periodic herbicide spraying is both infeasible with regard to environmental considerations and expensive (Wagner, 1971; Egler, 1958). The selective use of herbicides for woody plant control along with selective cuttings appears to be a more desirable technique where some control of vegetation is required.

The Bonneville Power Administration (1972) utilizes a variety of right-of-way maintenance techniques. Blanket spraying on a 5-year basis accounts, however, for 80% of their right-of-way maintenance program. Herbicide impacts and differences among the various kind of herbicides were reviewed by Kitchings <u>et al</u>. (1974). Shrub vegetation, at least in the eastern United States, may be commercially feasible for making pulp (Young, 1972). Perhaps the best approach to right-of-way maintenance is the system being developed by the B.P.A. (Anonymous, 1972), which involves removing only those trees necessary for line maintenance and designing the transmission line so that as little vegetation as possible needs to be disturbed during construction.

The maintenance of vegetation on access right-of-ways is similar to that described for the actual transmission line right-of-way. In most cases it is desirable to design the transmission line corridor so that the maintenance road is within the right-of-way for the transmission line (Dohrenwend, 1973). Roadside vegetation maintenance generally follows the principles previously outlined

(Egler, 1953b). Noxious weed control should be selective or it may promote reinvasion by removing the natural vegetative ground cover. The subject of weed-control has an extensive backlog of literature because of its agricultural importance. The National Academy of Sciences (1968) produced a general discussion on the subject.

C. Effects of Transmission Line Construction on Vegetation Within the Study Area.

Selecting the corridor for a transmission line is the most important factor in minimizing its environmental impact (Goodland, 1973; Kitchings, et al. 1974). Thus, identifying the vegetation within the corridor and knowing its susceptibility to disturbance, its economic and ecological value, and its potential for recovery is of utmost importance. The following section considers these factors for vegetation communities that may occur in the study area. A discussion of rare and endangered species in Montana and their occurrence in the study area is also included.

1. Studies of Vegetation Types that Occur Within the Study Area.

a. Grasslands

Mueggler and Handl (1974) described "habitat types" for grasslands and shrublands in western Montana. Their system follows the same system developed by Daubenmire (1970). Basically, this system allows identification of the typical overstory/understory vegetation (habitat type) that dominates at the climax phase of plant succession. Because the system is relatively new, its usefulness for mapping vegetation and for determining management implications is not yet fully known. Potential productivity data for grassland habitat types of the *Stipa comata*, *Agropyron spicatum*, *Festuca idahoensis*, and *Festuca scabrella* series has recently been described by Davis (1975).

Grassland vegetation types have been described by other authors in Montana. Morris (1946) classified grasslands in Montana on the basis of soil types (clay or sandy), precipitation levels, and grazing pressures. He mapped vegetation on the basis of both potential climax and existing types. Wright and Wright (1948) described Montana grasslands in south central Montana including portions of the study area. They classified grasslands into five tentative types based on the study of 10 relict grasslands across the central portion of the state. These included *Festuca idahoensis*[1], *Agropyron*

[1] The scientific and common names and abbreviations used in this report are listed in Appendix A.

spicatum, Stipa comata, Koeleria cristata, and Carex filifolia as dominant species with various combinations making up the different types. Although shrubby species occurred on grazed areas adjacent to the relict areas studied, in no case did shrubs make up a dominant portion of the vegetation where disturbance had not occurred. Brown (1971), however, described plant communities in the southeastern Montana badlands, and all types had some shrub species dominating. Continual erosion and disturbance were probably a dominant feature in the plant communities. This will be discussed in more detail in a later section concerning shrubs.

The Montana Agricultural Experiment Station (1973) has published a map depicting the common rangeland vegetation types in Montana. The basis for classification is not clear, but the map portrays obvious physical and vegetative differences (e.g. badlands, forested types, etc.). This map classifies grassland and shrublands in the study area as intermountain valley grassland and meadow, foothill sagebrush, and foothill grasslands. These types are general and include extensive overlap of those described by Mueggler and Handl (1974).

Pristine plant communities across the state have been also described by Ross et al. (1973). The data presented demonstrate how a relatively few plant species tend to dominate the range at a climax condition. Murray (1974) also published a detailed description of a pristine Festuca scabrella grassland. Britton (1955) studied a relict grassland in the Beaverhead Valley in Montana and found Agropyron spicatum with Poa sp. to be the dominating climax vegetation with Stipa comata predominating in heavily grazed areas adjacent to the pristine area. Anderson (1973) also has presented data on grasslands in Montana and has documented their changes in composition with grazing pressures. Mueggler and Harris (1969) have studied central Idaho grasslands similar to those in the study area. These authors have concluded that an Agropyron-Melica community and a Festuca-Agropyron-Antennaria community can be described.

Reitz and Morris (1939), Morris et al. (1950) and Stickney (1960) published papers dealing with the distribution and economic value of individual grass species in Montana. Jorgenson (1970) discussed the ecological aspects of western wheatgrass (Agropyron smithii, a common study area species) and the effects of sagebrush removal on wheatgrass growth.

Buchanan (1972) studied the effects of winter precipitation changes on the vegetation of the study area, and found that occurrence of the dominant plant species was correlated with snow depth. Cotter (1963) studied the response of various grasslands in the study area to disturbance by pocket gophers and other factors. He classified the vegetation into the following groups: *Stipa comata*-*Bouteloua gracilis*; *Stipa comata*-*Oryzopsis hymenoides*; *Stipa comata*-*Agropyron spicatum*; *Agropyron spicatum*-*Artemisia tridentata*; *Agropyron spicatum*-*Stipa comata*; *Festuca idahoensis*-*Artemisia tridentata*; *Festuca idahoensis*.

Much information is available describing the effects of grazing, clipping and other disturbances on various grasses. These will be discussed in a later section.

b. Shrublands

Mueggler and Handl (1974) have also classified shrublands in western Montana. These habitat types present some problems since many of the shrub species (e.g., *Rhus trilobata*, *Artemisia* sp., *Potentilla fruticosa*) increase with grazing pressure. Areas with a dominant shrub component may actually be grassland habitat types. Davis (1975) has reported potential productivity data for shrubland habitat types of the *Artemisia tridentata*, *Potentilla fruticosa*, and *Purshia tridentata* series.

Since sagebrush control is believed to increase rangeland productivity, much study has been given this species of shrub. *Artemisia tridentata* (big sage) communities were classified in central Montana by Smith (1969). Six communities were identified based on the association of this species with a variety of dryland grasses or sedges.

Payne (no date) described the effects of sagebrush spray programs on areas treated with 2,4-D in the Beaverhead National Forest. Johnson (1966) and Taha (1962) examined sagebrush reinvasion of controlled areas. The reason for successful reinvasion after treatment was not certain, although it appeared to be related to precipitation. Booth (1947) studied the influence of competition from native grass species on sagebrush stands in the Gallatin and Madison Valleys. His data revealed that big sage could not successfully compete with grass species in lightly grazed areas and that the competition would eventually eliminate *Artemisia tridentata* from the range. Daubenmire (1940), however, concluded just the opposite on *Agropyron spicatum* areas in Washington where

Artemisia tridentata occurred. The sagebrush there did not appear to compete with the grass species. He reiterated this opinion recently in a paper describing the development of steppe habitat types (Daubenmire, 1970).

Brown (1971) described the vegetation in southeastern Montana badlands. All of the vegetation types described had a shrubby dominant, including greasewood (Sarcobatus vermiculatus), big sage, skunkbush sumac (Rhus trilobata), and rocky mountain juniper (Juniperus scopulorum). Past disturbances on these sites were not discussed by the author.

Black greasewood was studied by Jameson (1952) to determine its utilization by livestock. The author found browsing of this species by livestock in areas near water. The nutrient value is not sufficient for full dietary requirements of cattle, but is of value.

Cook (1971) studied nutritive value and productivity of a variety of shrubs. McKell (1975) further described the function of shrublands and their usefulness to man. He critizes the widespread destruction of shrublands and calls for discriminating evaluation of shrub control programs.

Skunkbush sumac (Rhus trilobata) was studied with regard to its benefit to mule deer (Martin, 1973). It appears to be utilized by deer but not by livestock. Techniques for establishing shrub species on game ranges have been discussed by Medin and Ferguson (1972).

Patten (1968, 1969) described the sagebrush communities in the Madison Range near Yellowstone National Park. He reported a continuum of shrubland changes from riparian vegetation to drier sites, and described the successional pattern of lodgepole pine invasion into sites dominated by sagebrush.

Shrub species occurring in Montana have been described by Morris et al. (1962). Their economic importance is also mentioned by these authors.

c. Forest lands

Recently, Pfister et al. (1974) classified the forest vegetation in Montana into habitat types using a procedure similar to that of Daubenmire (1968). They used ordination techniques for determining the groups into which the vegetation was ultimately classified, and thus avoided the

inevitable argument of the "continuum" concept versus the "type" concept (Daubenmire, 1966; Cottam and McIntosh 1966; Vogl, 1966). Pfister et al. (1974) also evaluated the management and ecology of the vegetation types that they defined. However, with the exception of timber productivity, most of the evaluations are based on observations and field experience with the habitat types in question, rather than quantitative data.

The habitat types of the Deerlodge National Forest (U.S.F.S., 1974) have also been described, and the management implications for each type given in more detail. Most of the information is based on field experience of personnel in the Forest.[2] Pfister et al. (1971) have also described the resource potential of the habitat types described by Daubenmire and Daubenmire (1968). These include silvicultural implications, timber productivity, big game forage and cover, livestock forage production, water production, recreation attributes, aesthetic recovery, and resource protection considerations. Some of the habitat types described are similar to those occurring in the study area. The value of habitat type determinations in forest management has also been emphasized by Daubenmire (1969).

Patten (1963) has described the vegetation of the Madison Range in Montana, a range included in the study area. The forest vegetation types he identified are lodgepole, lodgepole-spruce-fir, spruce-fir, Douglas-fir, limber or whitebark pine, and aspen. The types were based on the dominant tree species present at the time of the study. The grouping of whitebark and limber pine into a single type may be questioned, as these two species have different habitat requirements.

Individual tree species have also been studied. Weaver and Dale (1974) discussed production and other aspects of whitebark pine (*Pinus albicaulis*) stands in Montana, including stands within the study area. They concluded that the low timber value of the whitebark stands makes them most suitable for water storage, wildlife habitat, and recreation.

Distribution and silviculture of Engelmann spruce and subalpine fir (*Picea engelmannii* and *Abies lasiocarpa*) have been discussed by LeBarron and Jemison (1953). The authors stress

[2]Personal communication with John Joy, Deerlodge National Forest. June, 1975.

the variability among sites and the need to use site-specific techniques in harvesting these species.

Picea glauca and Picea engelmannii were found to hybridize readily in Montana by Habeck and Weaver (1969).

Factors influencing the restocking of subalpine fir and spruce after burns was discussed by Stahelin (1943). This study concluded that in high-altitude areas, reestablishment of climax vegetation after severe burns may take very long periods of time.

Limitations in seed production of Douglas-fir (Pseudotsuga menziesii) were considered by Shearer and Schmidt (1965). Poor seed crops are rather common and rodent populations appear to be dependent on seed production.

Lodgepole pine (Pinus contorta) forests have been investigated by Moir (1969), who concluded that a distinctive area of climax lodgepole pine forest occurs in Colorado. Pfister et al. (1974) described only one climax type of lodgepole pine but have concluded that succession is so slow in what may be a non-lodgepole habitat type that classification as lodgepole pine community types is useful. The successional patterns of sagebrush to lodgepole and other conifers was described in detail for the Madison Range by Patten (1969). Lodgepole pine appears to be a seral species requiring disturbance for its establishment, since the cones are often serotinous and require fire to release seeds.

Many other publications deal with the silvics of the tree species that occur in the study area. Further information is available from the Intermountain Forest and Range Experiment Station at Ogden, Utah, and the Pacific Northwest Forest and Range Experiment Station at Portland, Oregon.

d. Miscellaneous Communities

Several types of vegetative communities occur in the study area which do not fall under the classification of grassland, shrubland, or forest. Because of their aesthetic appeal and interesting ecology, alpine areas have received considerable study. The habitat typing system of Mueggler and Handl (1974) has not included these types. Alpine vegetation is typically variable and fragile. Griggs (1938) investigated the forest vegetation of the northern Rockies and concluded that the timberlines are apparently not advancing and that some of the old trees present (1,800 years) indicate stable conditions.

Bamberg and Major (1968) performed extensive surveys of vegetation on calcareous parent materials in three different alpine areas in Montana. The vegetation community composition in the areas were determined by soil types. Choate and Habeck (1967) have described the alpine vegetation in Glacier Park and determined that plant species are distributed primarily on a moisture gradient. The susceptibility of alpine areas to disturbance has received much study and will be discussed later in this report.

Meadow communities provide unusual habitats. They are often found in poorly drained valleys, bottoms and swale areas. Mueggler and Handl (1974) described the *Deschampsia caespitosa*/*Carex* spp. habitat type, which occurs in wet meadows. Pond (1960) studied the effects of grazing on these areas and also included a description of the vegetation. *Potentilla fruticosa* occurred on the drier sites with *Salix* spp. on the moister areas. Patten (1963) described meadow vegetation in subalpine areas of the Madison Range. This vegetation would probably be the habitat types that Mueggler and Handl (1974) listed as *Festuca idahoensis*/*Agropyron caninum* and *Festuca idahoensis*/*Stipa richardsonii*.

Riparian vegetation also presents a unique and important type common in the study area. Foote (1965) described bottomland forests in western Montana, and concluded that riparian species composition is determined by the state of succession of the bottomland forests. Ordination techniques indicate that the cottonwood (*Populus trichocarpa*) and the quaking aspen (*Populus tremuloides*) have little overlap. Riparian vegetation was studied by Patten (1968), who determined that the bottom shrubland community of the Gallatin River forms a continuum along a moisture gradient. The sequence of shrubs goes from various species of *Salix* (moist) to the species *Artemisia cana* and *Artemisia tridentata* (dry). Their respective abilities to withstand browsing were also evaluated. Daubenmire (1970) included riparian vegetation in his habitat typing system of the Washington steppes. The species present were quite different from those of Montana communities.

Quaking aspen groves have been studied in areas similar to the study area. Groves in northern Montana were analyzed by Lynch (1955), while south of the study area in Wyoming they were studied by Reed (1971). It appears from these authors' findings that at least some of the aspen forest will maintain themselves; thus they are not simply a successional phase. This vegetation was not classified by Pfister *et al.* (1974) as a habitat type.

e. Endangered and Threatened Plant Species in Montana

The Smithsonian Institution (1975) has recently prepared a list of endangered plant species for the United States and has included the following as occuring in Montana:

1. *Silene spaldingii* - Endangered;
2. *Phlox missoulensis* - Endangered (Actually *Phlox kelseyi*, var. *missoulensis*);
3. *Grindelia howellii* - Threatened;
4. *Cryptantha sobolifera* - Threatened;
5. *Cardamine rupicola* - Threatened;
6. *Draba apiculata* var. *daviesiae* - Threatened;
7. *Rorippa calycina* - Threatened;
8. *Claytonia flava* - Threatened;
9. *Aquilegia jonesii* - Threatened;
10. *Penstemon lemhiensis* - Threatened.

Of these species, *Aquilegia jonesii* may occur in the study area on some of the higher limestone areas. *Penstemon lemhiensis* may also occur in the western portion of the area. The U.S. Forest Service has also published a list of rare, uncommon or endangered species for the Northern Region. This list is very extensive and many of the plant species listed are in the study area. This list, which includes an explanation of the classification system, is included in Appendix C of this report.

The concept of rare, threatened, or endangered species has not reached a consensus among plant taxonomists. Stickney (1974) commented on the concept and indicated that classification of endangered plant habitats, such as bogs, hot springs, etc., would be more desirable. DuMond (1973) listed guidelines for the selection of rare, unique or endangered plants. These guidelines emphasize many aspects of disturbed or limited habitats, historical effects, or unknown factors which limit a plant's distribution to a small area. The scarcity of pristine habitats is obvious on rangelands in Montana; only remnants still exist. The inventory by Ross *et al.* (1973) of near-pristine sites indicates that only very small acreages (such as pioneer cemetaries) still remain in a climax or near-climax condition.

2. Relationships of Study Area Vegetation to Wildlife

Wildlife species abundance and distribution are primarily determined by the available habitat. Vegetation is the most important component of this habitat. The information reviewed here relates only to wildlife studies addressing the various vegetation types in the vicinity of the study area.

The mountain goat was studied in the Spanish Peaks area, which occurs within the study area, by Peck (1972). He concluded that Cercocarpus ledifolius is an important winter food in the Jack Creek area while subalpine fir is probably important in higher areas. Saunders (1955) also studied the mountain goat in the Crazy Mountains, an area just northeast of the study area. The importance of alpine meadows for winter and summer food was stressed.

Blue grouse populations and habitat selection were also investigated within the study area in the Bridger Range (Mussehl, 1960). Grouse nested in the bunchgrass areas on the lower slopes in spring, while in late summer they were distributed at higher elevations in areas of Vaccinium scoparium.

Songbird populations were investigated in riparian habitats in the Bearpaw Mountains in northern Montana (Walcheck, 1969). This author found that disturbance by cattle on the study area did not severely affect nesting. The riparian habitats were classified into various subunits, depending on the dominant species present.

Whitetail and mule deer are also common game species within the study area. Both the detrimental and beneficial aspects of timber harvesting were discussed by various authors (Resler, 1972; Pengelly, 1963, 1972). The differential use of habitats within the subalpine fir and spruce zone in Montana by mule deer has received intensive study. The forest zones containing Xerophyllum tenax and Vaccinium were found to be important summer areas (White, 1960). Schwarzkoph (1973) studied mule deer in the Bridger Mountains and concluded that spruce/fir areas were important in the summer while Douglas-fir areas were important during winter. Bunchgrass prairie types were utilized primarily in the spring.

Knowlton (1960) studied the movement and food habits of moose in the Gravelly Range. He classified the vegetation in the area as willow bottoms, sagebrush-grass slopes and ridges, aspen timber, coniferous timber, subalpine meadows, and alpine meadows. During the summer he found that the subalpine meadows received the most use, while willow bottoms and the sagebrush-grasslands were used for cover.

Elk food habits, range use, and movements in the Gravelly mountains were also described by Rouse (1957). This author classified the vegetation as subalpine fir-Engelmann spruce, Douglas-fir, sedge-rush, sagebrush, fescue-wheatgrass, and aspen. He determined movements and wintering areas in the study areas. A study on the relationships of elk to the forest habitat types of Pfister et al.

(1974) is being completed by Les Marcum in Missoula and should provide more insight into the wildlife sustaining capabilities of various vegetation types.

Bayless (1969) has studied antelope habits and feeding behavior in central Montana. He classified the vegetative communities in the area as sagebrush-grassland, grassland, greasewood, greasewood/sagebrush, cropland, shale slope vegetation, abandoned meadow type and ponderosa pine woodland type. The sagebrush grassland type received the most use, regardless of season.

Wildlife utilization on the basis of habitat type classification was described by Pfister _et al_. (1974). The habitat types of the Deerlodge National Forest have been described in somewhat more detail (U.S.F.S., 1974). Current investigations at Utah State University are designed to more accurately assess the Forest Service habitat types as to wildlife capability.[3]

3. Susceptibility of Study Area Vegetation to Disturbance and Recovery Potential.

Disturbances from agriculture and logging in the study area have been extensive in the past and still continue in many areas. These disturbances vary greatly in magnitude, regardless of the cause; for example, human trampling results in moderate effects, extensive overgrazing has more severe impacts, and bulldozing can result in complete destruction. Power line construction will produce a variety of impacts, with tree removal having the most extensive effect on the vegetation. Access road construction will also accompany the transmission line and produce total vegetation removal over a smaller area. Heavy machinery will also crush vegetation during transmission line construction. The literature reviewed here considers grassland, shrubland, and forest vegetation separately. Other miscellaneous types are also discussed.

a. Grasslands

Grasslands have been studied extensively to determine the effects of grazing pressure on productivity. But few studies were performed until recently to assess the effects of severe disturbance (such as strip mining) and the ability of the land to establish native vegetation. Although exotic or successional vegetation can easily be established on severely disturbed grasslands, the climax vegetation is very slow in recovering.

[3]Personal communication with R.D. Pfister, June, 1975, Forest Sciences Laboratory, Missoula, Montana.

The recovery of abandoned fields has been the subject of several investigations. Nelson (1936) suggested that it may take 150 years for the native climax vegetation (*Stipa comata* and *Bouteloua gracilis*) to reestablish on rangeland that has been cultivated. Sixteen years after disturbance, the productivity of cultivated fields was approximately 50% that of the native rangelands. Whitman *et al.* (1943) also studied the abandoned fields in North Dakota and determined that 40 to 60 years would be required for the native climax vegetation (*Stipa comata* and *Bouteloua gracilis*) to again be established. The fields had good plant cover in 8 to 10 years and produced good hay crops. The productivity for grazing was diminished, however. Costello (1944) also investigated *Stipa comata-Bouteloua gracilis* grasslands that had been abandoned in Colorado. He determined that it would take 10 to 20 years for the native climax species to simply reestablish, let alone return to the original cover or productivity. Grazing pressure and climate were two factors in predicting direction and rate of succession.

Although the susceptibility to disturbance and the recovery rate of the vegetation on the study area have not been investigated, much information is available describing the response of vegetation types to grazing pressure or clipping. Since moderate disturbance by heavy machinery, like grazing, may reduce the photosynthetic capacity of the vegetation, response of grass species to grazing may indicate their ability to recover following transmission line construction.

Idaho fescue (*Festuca idahoensis*) produces less herbage and is less vigorous after even light grazing (Pond, 1960). Fire also reduces the productivity of this species where it grows in association with bitterbrush in Oregon (Countryman and Cornelius, 1957). Idaho fescue rangeland has also been studied by Mueggler (1972), who determined that aspect greatly affects production and that grazing should not begin until the fescue has headed out. Mueggler (1967) found that Idaho fescue is less susceptible to grazing than associated forbs. Mueggler (1970) also found that clipping reduced competition from other plants, resulting in a net increase in fescue production.

Bluebunch wheatgrass (*Agropyron spicatum*) is one of the more common grasses in Montana and has received much investigation. Heady (1950) discussed the growth form of this species and other common grasses in Montana. Mueggler (1972) discovered that bluebunch wheatgrass, like Idaho fescue, is given a competitive advantage by clipping which more than compensates for the effects of the clipping on plant vigor and production. Britton (1955) studied relict grasslands in the Beaverhead

Valley in Montana and determined that the ungrazed climax is Agropyron spicatum and Poa, while Stipa comata dominates grazed areas. Daubenmire (1940) has also investigated the effects of grazing on Agropyron spicatum and discussed this species competitiveness with Artemisia tridentata. The competitiveness between these species and response to grazing pressure does not appear to be constant throughout their range.

The condition and abundance of Agropyron spicatum, appears to be a good indicator of range conditions. In addition to the effects of clipping on Agropyron spicatum, Monroe (1949) noted that pulling on the seedlings resulted in a 95% mortality rate. Vogel (1960) discovered that protecting Agropyron spicatum and other grasses from sheep grazing produced little change in species composition over a 4-year period. Payne (1973) found that vigor of Agropyron spicatum was reduced more than that of Stipa comata when herbage was removed during May and June. Blaisdell and Pechanec (1949) determined that total herbage removal of bluebunch wheatgrass is most injurious when it occurs late in the year, when no substantial regrowth may occur.

Peterson (1962) studied factors affecting resistance of Stipa comata to heavy grazing, such as genetic variability and regrowth patterns under grazing stress. Branson (1956a) found that fertile clumps of this species were more productive than sterile clumps. Branson (1953, 1955) also determined that grazing does not remove the apical meristem in Bouteloua gracilis and Stipa comata, while it may remove it in the wheatgrasses. This probably explains the resistance of the former species to heavy grazing, and the relative susceptibility of the latter.

Bouteloua gracilis shows a variable response to grazing pressures in different parts of its range (Turner and Klippee, 1952; Ellison, 1960). It appears to decrease under moderate grazing pressure but often increases under intensive grazing pressure (Branson 1955, 1956b).

Jameson and Huss (1959) studied Andropogon scoparius, a plant that occurs rarely in the study area. The effects of clipping were more severe early in the season, while late clipping actually increased total production.

Studies by Driscoll (1957) showed that vigor of elk sedge (Carex sp.) is reduced by clipping but that production changes little. Agropyron smithii responded to clipping in a way similar to Agropyron spicatum (Monroe, 1949). Balsamorhiza sagitata appeared to be more resistant to clipping than blue-

bunch wheatgrass (Blaisdell and Pechanec, 1949).

The effects of grazing and harvesting on grass succession and productivity have been reviewed by Ellison (1960) and Jameson (1963). Additional information used in judging range conditions and trend has been published by Arnold (1955) and Ellison (1949). Morphological factors affecting resistance of various grass species to grazing has been discussed by Branson (1953, 1955).

Studies of the effects of trampling on grasslands have been primarily confined to recreational areas. The effects of human trampling on vegetation have recently been reviewed by Liddle (1975). Most studies have concerned vegetation types not found in the study area. Beardsley and Wagar (1971) found that grasses are generally able to withstand trampling better than forbs in forested areas in Utah. Dale and Weaver (1974) compared the trampling effects of motorcycles, horses, and hikers on Idaho fescue grasslands. Horses had the most impact, followed by motorcycles, and finally hikers. Cieslinski and Wagar (1970) also studied the effects of trampling on grasslands with some forest overstory. They determined that southwest aspects and flat or gentle-slope areas had the poorest vegetation survival, while the steeper and more northerly slopes had the best vegetation survival. Effects of trampling on forest vegetation will be discussed later.

The literature reviewed here does not include all information available on the effects of grazing or other disturbances on the study area grass species. Only investigations that were conducted in the study area that appear to be relevant in estimating effects of disturbance on the grasslands of the study area have been included. Reseeding and planting recommendations for grassland reestablishment were not reviewed. Honkala (1974) has published an excellent bibliography on surface mining and mine reclamation that includes most of the pertinent references on revegetation of grasslands and other plant communities.

b. Shrublands

The impact of disturbance on shrublands has received little attention. In fact, much of the literature and research has been devoted to finding methods of destroying shrub vegetation in order to increase grass productivity. Recently, however, the value of many shrubs on arid lands has been recognized (McKell, 1975). Garrison (1953) investigated the effects of range shrub clipping to determine wildlife usage capabilities. The shrubs investigated were Chrysothamnus

nauseosus, Cercocarpus ledifolius, and Purshia tridentata, all of which occur in the study area. Most of the plants could withstand 50 to 60 percent utilization and still maintain their productivity. Medin and Ferguson (1972) discussed the problems of reestablishing shrubs on game ranges in the northwest, but did not discuss their vulnerability. Booth (1947) determined that sagebrush (Artemisia tridentata) could not successfully compete with grasses and would be eliminated. Robertson (1947) determined that sagebrush and grasses are competitive, since removal of sagebrush consistently increased range grass production. Johnson (1966) and Taha (1972) have studied sagebrush reinvasion after removal, and found that exposure, precipitation and the effectiveness of the control treatment all affect reestablishment of sagebrush. The control treatment demonstrated that the establishment of new seedlings is inversely related to the density of the sagebrush stand. A study of the effects of chemical sagebrush control on vegetation just west of the study area has been conducted by Payne (no date). The 2,4-D spraying caused Artemisia tridentata and Artemisia tripartita to decrease on all sites. Chrysothamnus nauseosus and Rosa woodsii increased on more sites than they decreased. Symphoricarpos albus and Tetradymia canescens both decreased on the majority of the spray sites.

Artemisia increased on some of the older sties, indicating reinvasion. Shrubland response to grazing intensity has been extensively studied by Dook (1971). Approximately 50% utilization of the common species would be adequate to insure continued productivity.

In general, the studies on shrublands have been directed toward their destruction, rather than their preservation. The paucity of literature makes it difficult to determine the ability of the various shrub species to withstand moderate disturbance. The species described by Mueggler and Handl (1974) as "increasers" are probably most resistant to grazing disturbances. The Artemisias, Rhus trilobata, and Potentilla fruticosa are the "increaser" shrubs while Purshia tridentata and Cercocarpus ledifolius are "decreasers." The sensitivity of these species is probably related to their palatability rather than their ability to withstand physical disturbance.

c. Forest lands

Forest lands that occur in the study area have long been subject to logging and heavy grazing pressures. Although most of the available literature addresses these subjects, some recent studies deal with trampling in forested areas and are discussed here.

Pfister *et al.* (1974) determined the timber growth potential for the various forest habitat types that occur in the study area. In addition, they discussed the recovery potential of the various habitat types following logging and the probability of erosion.

Habitat Types of the Deerlodge National Forest (U.S.F.S., 1974) includes information on regeneration of areas disturbed by logging. Pfister *et al.* (1971) discussed the probability of natural regeneration succeeding on various habitat types of Idaho following a variety of site preparations.

Clearcutting of forest vegetation and the resulting nutrient loss have been discussed by several authors (Bormann *et al.*, 1968; Likens, *et al.* 1969). The importance of shrubby species in returning a forest ecosystem to a steady state of nutrient cycling was discussed by Marks and Bormann (1972). The effects of clearcutting and road building on soil in Douglas-fir and ponderosa pine timber stands were studied by Megahan and Kidd (1972). In a logging operation without roads, sediment was 60% greater than in a control drainage. A logged area with roads had extensive erosion and soil movement, with sediment 7500% greater than in the same control. The response of the Douglas-fir/*Physocarpus malvaceus* habitat type to clearcutting was studied by Wagner (1970). He determined that browse production was best after site burning. Stahelin (1943) discussed the problems of natural restocking in high-altitude spruce and subalpine fir sites. Many factors affect restocking, but in general, some seed trees are needed for prompt regeneration following vegetation removal by fire or other major disturbance.

Effects of trampling on forest areas have been investigated within the study area by Dale and Weaver (1974a, 1974b) and Dale (1973). They concluded that *Vaccinium scoparium*, *Symphoricarpos albus*, *Physocarpus malvaceus*, and *Abies lasiocarpa* decrease with trampling. *Pseudotsuga menziesii* was the only woody plant that increased with trampling. The response of forbs to trampling varied. Beardsley and Wagar (1971) determined that vegetation of the understory in coniferous stands is difficult to reestablish once it has been killed by trampling. Understory vegetation recovered much more quickly under open canopies than under dense canopy covers. Cieslinski and Wagar (1970) described the effects of slope and aspect on recovery of trampled understory vegetation in relatively open-canopy forests. Soil temperature appears to affect recovery: steep northern slopes recover faster than less steep southern slopes. LaPage (1967) listed the response of many forbs to trampling.

Many additional studies on the silviculture of various tree species have been conducted by the U.S.D.A. Forest Service research laboratories in Ogden, Utah, and Portland, Oregon. These generally address the problems of regenerating timber species after logging and not the reestablishment of the total vegetation. Available information relating to habitat types has been reviewed by Pfister _et al_. (1974) and provides our basis for predicting impacts of power line construction on various forest types.

d. Miscellaneous vegetation types

The response of riparian vegetation types to browsing has been discussed by Patten (1968). The willow species in the wetter areas appear to be able to withstand browsing pressure. _Artemisia cana_ replaces the other willow species where grazing pressure is heavy. Abundant moisture appears to favor the ability of plants to withstand heavy browsing. Lynch (1955) and Reed (1971) discuss the roles of livestock disturbance and fire in the aspen groveland communities.

The response of alpine communities to trampling and their recovery have been investigated. Willard and Marr (1970, 1971) studied the impact of human activity and the rate of recovery of alpine areas in Colorado. They concluded that the climax vegetation will take hundreds of years to completely reestablish. Bell and Bliss (1973) also studied alpine disturbances in Olympic National Park in Washington. Certain areas in the alpine zone recovered quickly from light human trampling but highly disturbed areas showed little recovery after a 30-year period.

Ellison (1949) discussed the problems of establishing vegetation in subalpine meadow areas. This vegetation has apparently suffered extreme grazing abuse in many areas in the Rocky Mountains. A study by Pond (1960) indicated that meadow species composition was changed quickly by simulating heavy grazing. However, clipping at the end of the growing season had little effect on community species composition. Moderate clipping also had little effect, although production was decreased in some cases.

D. Summary of Literature Review.

This review has been an attempt to assimilate information on the impact of power line construction on vegetation, with particular emphasis on the study area. Unfortunately, few references directly address transmission line impact on vegetation. Vegetation studies that have been conducted within or near the study area have been

the prime subject of review. Most of the available information deals with the impact of agricultural practices or timber harvesting on the study area vegetation; hence our concentration on these references.

More information is definitely needed on the forest habitat types developed by Pfister et al. (1974) to evaluate their response to transmission line construction. With the exception of timber productivity, most available information on these types is observational. The grassland and shrubland habitat types of Mueggler and Handl (1974) do not include information on disturbance, except for a sketchy "decreaser-increaser" rating provided for the common species. Davis (1975) has recently provided information on the potential productivity of some of the habitat types. The studies by Daubenmire (1970) include very little management information for the various grassland and shrubland habitat types.

Extrapolating the effects of grazing or simulated grazing on various grass species to specific habitat types may be questioned. However, this appears to be the only approach available for this study. Therefore, the information cited in this section for grassland and shrubland vegetation was heavily relied on in Section III in developing a methodology for determining transmission line impacts on the study area vegetation.

More extensive information is available on the general subject of vegetation disturbance and recovery. A section in the Bibliography includes references not pertinent to the immediate problem but of possible interest to the readers of this report. Bibliographies, books, and reviews are also listed separately in the bibliography.

III. RATIONALE FOR EVALUATING THE IMPACT OF TRANSMISSION LINE AND ACCESS ROAD CONSTRUCTION AND MAINTENANCE ON PLANT COMMUNITIES

A. Introduction.

This section concerns the techniques used in mapping vegetation in the Clyde Park-Dillon power line corridor study area. It describes the rationale for determining the impact of the power line on each of the mapping units. The impact on each vegetative unit was determined from information gathered in the field and from the preceding literature review. The limitations of the mapping procedure and sources of error are also described.

B. Vegetation Mapping Techniques.

Two methods were used to map the vegetation in the study area. Non-Forest Service lands were mapped using extensive field checking procedures. Forest Service lands were mapped by relying on existing Forest Service data. The methods are described in the following sections.

1. Non-National Forest Lands

The non-National Forest lands of the study area are primarily of grasslands and shrublands. Mueggler and Handl (1974) have described this vegetation for western Montana using the habitat type method developed by Daubenmire (1970) for the steppe vegetation of Washington. The value of this method is that it describes potential vegetation of an area instead of the existing vegetation, which may be a reflection of recent land use practices. The method has some limitations, which the authors have described. For instance, they did not utilize ordination techniques or cluster analyses as the basis for determining vegetative types. Instead, they used the dominant species they believed to be of value in determining vegetation types. Further, the authors did not use pristine vegetation types in developing their habitat types. The widespread disturbance caused by present and past grazing makes such data difficult to obtain. Thus, the vegetation units the authors developed may reflect the vegetation of seral or disturbed sites rather than the potential climax vegetation.

This is particularly true for the shrubland habitat types. Whether an area was classified shrubland, grassland, or herbland was often determined by grazing history. We encountered this problem frequently in determining habitat types for *Artemisia*, because

exclosure and fenceline contrasts indicated that this species would not be common in many areas where it now exists if grazing practices were altered. Studies by Booth (1947) within the study area support the contention that this species will not successfully compete with grasses if grazing is light.

The unnatural abundance of successional species due to grazing also made it difficult to determine climax vegetation for grasslands within the study area. Some grass species are able to withstand grazing better than others, thus present grass domination may reflect grazing pressure rather than actual habitat types. Thus, some of Mueggler and Handl's habitat types may reflect present vegetation rather than potential.

Despite the limitations outlined above, we mapped the vegetation of the study area using this key. The potential impacts of transmission line construction should not be severely affected by the possible confusion of certain habitat types. Furthermore, the advantages of using a habitat typing system for grasslands and shrublands as well as for forests out-weighed the disadvantages of the Mueggler and Handl system.

We delineated non-forest lands that had been reseeded, cultivated, irrigated, or cultivated and allowed to regrow as agricultural lands. Forest vegetation that appeared severely altered by recent logging we delineated as "clear cut" or "selective cut".

We mapped several common types of vegetation not classified by Mueggler and Handl (1974) and Pfister et al. (1974) during the course of this study. These included two riparian communities, aspen grovelands, Rocky Mountain juniper (Juniperus scopulorum) - dominated areas, saline areas dominated by Distichlis stricta, Agropyron smithii, and Spartina, and a limited area dominated by Andropogon scoparius and Calamovilfa longifolia. These types will be discussed later.

We classified forest lands outside the National Forest using the habitat type key of Pfister et al. (1974). Although many of these areas were also subject to grazing disturbance, usually there were enough protected sites within a stand to determine the correct habitat type. Unlike the grassland species, many of the key forest species were shrubs not subject to total disappearance with heavy grazing. Forest lands were also classified as to the timber size (greater or less than 9 inches d.b.h.[4] on the average) and stocking (greater or less than 40% forest canopy coverage).

[4]diameter at breast height.

The mapping procedure involved preliminary interpretation of aerial photographs of the study area (scale 1:65,000 or 1:125,000). Final habitat type mapping followed on-the-ground investigation. During the ground checking, extent and season of wildlife use were noted. Grazing pressure, slope, aspect, topography, and elevation of many of the sites were recorded. Percent ground cover of the dominant plant species was recorded along with notes on disturbances. Undisturbed or lightly disturbed areas were recorded for future investigation of climax communities. Range was also classified as poor, fair, or good for each habitat type.

2. National Forest Land

On National Forest land in the study area we used a different mapping procedure. Because of the season and time constraints, existing Forest Service data and other sources were utilized to determine habitat types.

In the Gallatin National Forest, range maps and timber type maps provided the bulk of the information. Vegetation maps by Patten (1963) and Dale (1973) provided information on timber types and dominant species. Other studies involving vegetation surveys were also reviewed (see literature review section for additional references). In the Beaverhead National Forest, range and Ecological Land Unit information was consulted in addition to timber type maps. A range map of the Tobacco Root Mountains was used for understory delineation in this part of the Deerlodge National Forest, with timber type maps used for the overstory. Habitat type information is presently being gathered in the Beaverhead but is not yet available for extensive areas and was not used in this survey.

Our mapping strongly relied on habitat type data collected by the Intermountain Forest and Range Experiment Station in the development of the key by Pfister et al. (1974). In fact, it was the only data that could be relied on to provide accurate habitat type information for the study area. Their data from the areas immediately south of our study area were also used in determining probable slope, aspect, and elevation of the various habitat types. These data are summarized in Table I. The range of the data collected and the number of sites for each type are also included in the table. The data were broken down for the Gallatin National Forest, the Beaverhead National Forest, and the portion of the Deerlodge National Forest within the study area. As data were available from only one site for many of the habitat types in the study area, inferences about the range of the habitat types should be made with caution.

Our mapping procedure employed aerial black and white photography (1:65,000 scale). Habitat type boundaries were determined by evaluating Intermountain Station data with respect to aspect and elevation. The distribution of the habitat types of the Madison-Beartooth area and the Dillon-Lima area portrayed by Pfister et al. (1974) were also relied upon during our delineation procedure (illustrations included in appendix). The Tobacco Root and Gravelly Mountains were thought to have a habitat type distribution somewhat between the Madison-Beartooth types and the habitat types of the Dillon-Lima area. Deitschman (1973) has outlined the general procedure that we followed except that we obtained virtually no field data. We relied on the point data of the Intermountain Station.

The differences among habitat types, timber types, and soil types has been portrayed by Daubenmire (1973). In relying strictly on the available Forest Service data, we have probably confused types within a series (Habitat type hierarchial grouping based on the dominant overstory species). Some confusion between series also may have occurred because we lacked information on non-commercial forests and the understory species in timber stands. These errors, should make little difference in predicting transmission line impacts, since the types in question respond similarly to disturbance.

Timber size and stocking were generally transferred directly from Forest Service timber type maps. The timber was classified as less or greater than 11 inches d.b.h.; stocking was classified less or greater than 40%. Areas disturbed by logging were delineated as "clear cuts" or "selective cuts." Because of the lack of information, range condition on National Forest lands was not included. However, incidental field checking revealed they followed patterns similar to those of the non-forested lands.

3. Limitations of Vegetation Mapping Methods for Non-National Forest Land.

The limitations of the habitat type method of describing vegetation has been previously discussed, particularly for shrublands and grasslands within the study area. Widespread disturbance of vegetation makes it difficult to determine the climax community in many cases.

Our mapping procedure was subject to limitations of scale as communities of less than approximately 80 acres were not defined. Some of the habitat types that occurred regularly on the study area were rarely this large in area; and were consequently not mapped. We did not have access to some areas of private land within the study area, thus field checking was not always possible.

We inferred the vegetation of these areas from that present on surrounding areas. Areas that have not been cultivated, but have been irrigated, we classified as altered, although in some cases the native flora still persists. Many areas were so severely disturbed by overgrazing that we inferred habitat type on the basis of vegetation located some distance away. *Artemisia tridentata* stands were usually typed as grassland types, since most of them appeared to have been heavily grazed in the past. As mentioned previously, there is no information indicating that they form the climax type in this region, although Daubenmire (1970) contends they are climax vegetation in eastern Washington.

4. Limitations of Vegetation Mapping for National Forest Lands

The Forest Service land mapping involved little field checking. Although timber type maps and range maps provided some insight into the vegetation on the national forests in the study area, they did not provide an adequate source of data for habitat type determinations. The range maps were inconsistent in their listing of dominant species other than grasses. For example, *Vaccinium* (huckleberry) species were sporadically listed and certain shrubs such as *Physocarpus malvaceus* and *Symphoricarpos albus* were rarely listed. The range maps also lacked data for most areas having little range potential. Forbs of little importance to livestock, such as *Arnica cordifolia*, were not included in the vegetation descriptions, even for areas in which they were the obvious dominant species. Timber type information had large areas listed as non-commercial forest without any reference to species present. Many areas labeled lodgepole or other timber species provided no insight as to the probable climax species or as to the reproducing species in the stand although more than one species of mature trees often occurred in many stands, only one of the species was shown on the timber type map. The available habitat type data from the Intermountain Station were useful but limited. Ecological Land Unit information provided little new data that could be used to determine habitat types. The techniques and recommendations suggested by Deitschman (1973) could easily be implemented on large National Forest areas during a single season by a small crew.

C. Mapping Unit Descriptions

The mapping units used in this study are discussed in this section. The units are grouped into the series used by Mueggler and Handl (1974) and Pfister *et al*. (1974) for purposes of this discussion. The field data gathered for grassland and shrubland types are summarized in Table II.

1. Grasslands

a. STIPA COMATA SERIES

Only the habitat type Stipa comata/Bouteloua gracilis occurs in this series. We examined a climax community of this type near Lewis and Clark Caverns. The soil type appears to eliminate Agropyron spicatum in this area as it is associated with Stipa comata and Bouteloua gracilis in adjacent areas. Agropyron smithii is associated with this habitat type in areas protected from grazing. In heavily grazed areas, Bouteloua gracilis forms a mat-like covering over much of the ground and is the dominant species. Also, in heavily grazed areas, which is the usual situation, Agropyron spicatum could have been eliminated, thus confusing this type with the Agropyron spicatum/Bouteloua gracilis or Agropyron spicatum/Poa sandbergii habitat types. We classified much of the flat bottomland along the Madison River as this type but heavy grazing usually made the identification tentative. Antelope are common in this type throughout the study area. This is apparently the lowest and driest of the grassland habitat types of the study area.

b. AGROPYRON SPICATUM SERIES

Three habitat types of this series occur on the study area. Agropyron spicatum/Bouteloua gracilis habitat type is found on the lower, dry, flat areas adjoining the Stipa comata/Bouteloua gracilis type. It appears to occupy areas with only slight increases in moisture. Stipa comata is always associated with this type. Antelope are common here also. Agropyron spicatum decreases with grazing and may have disappeared at potential sites, thus causing confusion with the Stipa comata/Bouteloua gracilis type previously described. The ability of Bouteloua gracilis to increase under grazing pressure makes it of questionable value as an indicator of climax vegetation types.

Agropyron spicatum/Poa secunda occurs on the next driest site at higher elevations. The soils appear to be rockier than on other sites but detailed examination was not made. Artemisia tridentata is often associated with this type and confusion can easily be made between this type and the Artemisia tridentata/Agropyron spicatum habitat type. Stipa comata is also is also dominant in this habitat. In areas of light grazing pressure, little Poa was observed; it appears to be an increaser in this habitat type. Because we conducted this study in early spring, the Poa species could not be identified;

thus the Poa associated with this type was determined by inference. Elk often use this type as winter range.

The Agropyron spicatum/Agropyron smithii-dasytachyum habitat type is found in lower areas on apparently different soil types. Changes in moisture, aspect, or elevation do not distinguish this type from the others in this series. The type is often associated with swales and heavier soils. We observed more deer sign and less antelope sign on this type than on others during this study.

c. FESTUCA SCABRELLA SERIES

We found no grasslands of this type in the study area. Stickney (1960) reported this species as rare within the boundaries of the study area, although its presence has been documented at several locations. It is easily removed by grazing pressure, and possible locations within the study area may be obscured by past grazing.

d. FESTUCA IDAHOENSIS SERIES

This series is one of the most common grassland types within the study area. Festuca idahoensis/Agropyron spicatum and Festuca idahoensis/Agropyron smithii dominate the higher elevation grasslands below the forested lands. The types appear to be separated on the basis of soil differences, as they often are found at similar altitudes and exposures. The Festuca idahoensis/Agropyron smithii type occurs often in swales within the Festuca idahoensis/Agropyron spicatum habitat type. Both of these types are used extensively as deer and elk winter range.

The Festuca idahoensis/Carex filifolia; Stipa richardsonii, Agropyron caninum, and Deschampsia caespitosa habitat types undoubtedly occur in the study area on the National Forest lands. Ground checking revealed these areas were rarely extensive and usually associated with the Festuca idahoensis/Agropyron spicatum habitat type. They were grouped with this latter type in mapping the National Forest lands. High-elevation areas, however, were usually typed as Festuca idahoensis/Deschampsia caespitosa when they extended beyond the elevation limits of Agropyron spicatum. Detailed field checking would be required in the National Forests to accurately type the higher altitude meadows and grasslands.

In many areas, Artemisia tridentata was associated with the Festuca idahoensis types, which made it difficult to determine whether the type should belong to this series or the Artemisia

tridentata series. In most cases, the area was classified within the Festuca idahoensis series, since Artemisia is probably not a dominant climax species.

e. DESCHAMPSIA CAESPITOSA SERIES
(Deschampsia caespitosum/Carex H.T.)

This is the vegetation type of the mountain valleys and meadows which joins the riparian woody habitats. This type was generally of small acreage and was grouped with the adjoining riparian vegetation or grasslands during mapping.

f. ELYMUS CINEREUS SERIES

Vegetation types with this species as the obvious dominant are common in the study area but occur only in small acreages. We observed this type near riparian communities which adjoin drier sites. Because of the small acreage it was grouped with the riparian communities or the adjoining grasslands.

g. Other Grassland Types

Two other grassland communities were identified within the study area that were not recorded by Mueggler and Handl (1974) Andropogon scoparius was found associated with Calamovilfa longifolia on a small area at an elevation of about 5600 feet. It occurred on the south-facing slope of an east-to-west running draw with a slope of 10-25%. The soil was thin with small, rounded boulders 4 to 8 inches in diameter. The site had moderate grazing pressure from cattle. Species present and approximate ground coverage were as follows:

	Coverage Percentage
Andropogon scoparius	60-80
Calamovilfa longifolia	5-10
Artemisia frigida	5
Carex filifolia	5
Bouteloua gracilis	15-20
Juniperus scopulorum	10
Pinus flexilis	5
Alyssum alyssoides	50
Opuntia polyacantha	5
Chrysothamnus nauseosus	trace
Artemisia tridentata	less than 5
Lomatium sp.	less than 5
Rosa sp.	less than 5 (up to 25 in swales)
Bromus tectorum	5

This type of vegetation is more common in eastern Montana and North Dakota. The reason for its limited distribution within the study area is not clear.

In the Paradise Valley soils with high salt content were observed in low swales. Distichlis stricta, Spartina, and Agropyron smithii were the dominant vegetation in these areas. Daubenmire (1970) observed a similar vegetative type with limited distribution. Quantitative data were not obtained for this type.

2. Shrubland

The shrubland series presented difficulties, particularly the Artemisia types. Often adjacent grasslands were apparent because of fence line contrasts or lack of disturbance. Mueggler and Handl (1974) require type determination by noting whether the aspect is shrubby. This was not defined and made it difficult to assign types. The literature indicates that many shrub species respond differently to competition with other species throughout their range. This may be caused by genetic differences (ecotypic variations), or it may be related to species physiology and inter-species relationships. It is doubtful that the conclusions of Daubenmire (1970) with regard to shrubby vegetation in Washington will apply to the same species in Montana. Because of the importance of many of the shrub species to livestock and wildlife, it would be valuable to include them in a vegetation description as community types; management of an area may be very much affected by their presence. The following "habitat types" for shrublands within the study area must be considered with regard to this discussion.

a. ARTEMISIA ARBUSCULA SERIES

As with most of the other species of Artemisia, Artemisia arbuscula thrives in heavily grazed areas. The Artemisia arbuscula/Agropyron spicatum habitat type occurs on slopes similar to those containing the Artemisia arbuscula/Festuca idahoensis type, but at lower elevations. The Artemisia arbuscula/Festuca idahoensis type is rare and only one stand was examined. Artemisia tridentata is occasionally mixed in with this type. Artemisia arbuscula is generally found on shallower, rockier soils than Artemisia tridentata. Slight use of this series by deer and antelope was observed. The Agropyron spicatum/Poa sandbergii habitat type is often associated with this series. The Artemisia arbuscula series may be a successional stage in the development of climax vegetation of the Agropyron type.

b. ARTEMISIA TRIDENTATA SERIES

Artemisia tridentata is the most common shrub type in the study area. Extensive control programs have attempted to eradicate these stands to increase rangeland productivity. The Agropyron spicatum and Festuca idahoensis habitat types of this series are common, but Festuca scabrella was not observed. This series was usually not identified because of the apparent seral nature of Artemisia tridentata in most areas. Only in a few areas did it appear to be able to maintain itself as the climax species. Usually the conclusions for this type can be interchanged with those drawn for the Festuca idahoensis and the Agropyron spicatum series. Artemisia tridentata appears to require moister areas and deeper soils than did the Artemisia arbuscula series. It often occurs only in swale areas on the steeper slopes. Deer, elk, and particularly antelope are associated with this type. The management of these areas should parallel that of the associated grasslands, except when the presence of Artemisia tridentata dictates modification. (None of the sites that we closely examined could be assigned this series with confidence.) Areas delineated this habitat type should be considered interchangeable with the associated grassland type when evaluating impacts.

c. ARTEMISIA TRIPARTITA SERIES
(Artemisia tripartita/Festuca idahoensis H.T.)

This habitat type was found in the western portion of the study area north of Alder. It may be seral, occurring in areas where Artemisia tridentata has been disturbed. It may occur at higher elevations on National Forest land in association with Festuca idahoensis grasslands, but Forest Service data did not separate this species from the other sagebrush. The lack of information and the seral nature of the species were the reasons this type was grouped with the Festuca idahoensis series. Artemisia tripartita is found in restricted areas, not associated with Idaho fescue but with drier grass species. When this occurred, the habitat type mapped was the grassland type which occurred on adjoining grasslands.

d. ARTEMISIA PEDATIFIDA SERIES
(Artemisia pedatifida/Festuca idahoensis H.T.)

This shrub was not encountered in the study area. It appears rarely in some areas east of the study area and has a very limited distribution within the area.

e. POTENTILLA FRUTICOSA SERIES

The Potentilla fruticosa/Festuca idahoensis habitat type probably occurs within the study area on limited acreages in the National Forests. The Forest Service data contained no information on its distribution. These types were grouped with the Festuca idahoensis types during the mapping.

f. PURSHIA TRIDENTATA SERIES
(Festuca idahoensis and Agropyron spicatum H.T.'s)

The Purshia tridentata series occur rarely if at all within the study area. Small, scattered patches of these two types occur within the National Forest boundaries, but these were too small in area to be mapped by our procedure. It is usually found on decomposed granite rock with scattered Pseudotsuga menziesii overstory. Artemisia tridentata, Cercocarpus ledifolius, Juniperus scopulorum, and Agropyron spicatum are commonly associated with this vegetation type. As this shrub is a highly palatable browse species, areas where it does occur should be considered valuable.

g. CERCOCARPUS LEDIFOLIUS SERIES
(Cercocarpus ledifolius/Agropyron spicatum H.T.)

This type occurs in many parts of the study area. It is characteristic of rocky areas on moderate slopes. Exposure does not appear to restrict this type, although it is most frequent on south slopes. It often forms a mosaic with Rhus trilobata types, and Douglas-fir or limber pine. The steep canyons along the Madison River are its most common location. As the patches are often less than 80 acres, we grouped the Rhus trilobata/Agropyron spicatum and possibly other types with this type in the mapping procedure. It is an important browse species in the study area; deer use varies from light to very heavy, with prominent high-lining on some shrubs. According to the literature, it is an important browse plant in winter for mountain goats in the Bear Trap Canyon area.

h. RHUS TRILOBATA SERIES

Within the study area Rhus trilobata/Agropyron spicatum was the only habitat type identified for this series. This type occurs on very steep and dry slopes. The five sites we recorded were all on easterly or southerly exposures. It is often associated with Cercocarpus ledifolius on the rockier areas. Only one site had signs of wintering deer. This shrub is supposed to be palatable to mule deer for winter browse but not to cattle, although it is not as preferable as Cercocarpus ledifolius.

i. SARCOBATUS VERMICULATUS SERIES

Sarcobatus vermiculatis/Agropyron smithii and Sarcobatus vermiculatis/Elymus cinereus habitat types occur on the study area. Sarcobatus vermiculatus provided problems in determining habitat types because it increases under disturbance. Although it occurs in small, distinct areas, because of its preference for poorly drained soils it may not be a climax species on these sites. One area cultivated in the late 1940's presently supports a heavy stand with little evidence of any major disturbance. Cattle use is also uniformly heavy on most of these sites because of close proximity to water. Most of the habitat types delineated for this series were Sarcobatus vermiculatus/Agropyron smithii, as these covered the larger areas. Often they were found adjacent to Agropyron spicatum/Agropyron smithii-dasytachyum habitat types. Sarcobatus vermiculatus/Elymus cinereus appears to have a more limited distribution along drier alkaline areas. Neither of these types are common in the study area. No wildlife use was observed in the stand examined.

j. Other Shrub Types

Juniperus scopulorum, a very common species within the study area, has not been considered to be a habitat type associate by either Pfister et al. (1974) or Mueggler and Handl (1974). During the study, several sites were examined that did not fit the key type descriptions of these authors. Three sites examined had southeasterly exposures, were on moderate slopes or ridgetops, and ranged between 4400 and 4800 feet in elevation. Percent ground cover of Juniperus scopulorum was 20, 60, and 75% for these sites. Agropyron spicatum and Pinus flexilis were associated with this type on all three of the sites, but coverages were 20% or less for each species. Festuca idahoensis was present on two of the sites. Rhus trilobata, Artemisia arbuscula, and Artemisia tridentata were present on only one of the three sites. Mule deer used one of the sites as winter and spring range. Livestock use was heavy on two of the areas and light on one. This type is distinguished by the dominant Juniperus scopulorum stands.

3. Forest Lands.

Forest lands within the study area were generally not field-checked. Forest Service data were used in mapping, and only incidental observations were made during the study. Some of the Pinus flexilis stands were examined, as they occurred

primarily on non-National Forest land. The elevation, exposure, and aspect data for the various habitat types located within the study area are listed in Table I. The distribution of the habitat types with elevation for the eastern and western portions of the study area are illustrated in the appendix figure taken from Pfister et al. (1974). Each series is discussed in the following sections.

a. PINUS FLEXILIS SERIES

Limber pine occurs throughout the study area. This type has heavy elk and deer usage in the winter. Stocking of this species is usually quite low; some trees have large diameters, but seldom exceed 40 feet in height. Juniperus scopulorum is usually associated with this type, and Rhus trilobata and Cercocarpus ledifolius are also common associates. The three types in this series (Festuca idahoensis, Agropyron spicatum, Juniperus communis) occur within the study area. Douglas-fir (Pseudotsuga menziesii) is often associated with both of these types. Juniperus communis occurs most commonly on limestone soils with heavy litter and little understory. Pure stands of limber pine are uncommon. The Pinus flexilis/Agropyron spicatum habitat type is probably the driest forest type in Montana. It occurs on steep, southerly slopes in the study area. The Pinus flexilis/Festuca idahoensis habitat type occurs on more northerly exposures or at higher elevations. In the study area, it was observed on forest edges or thinly stocked ridges only. Elk appear to use this type more often than the one with the understory dominated by Agropyron spicatum. This series was the only forest vegetation that commonly occurred outside of National Forest boundaries. Pfister et al. (1974) examined only one stand of limber pine with Idaho fescue in the study area while developing their habitat types.

b. PSEUDOTSUGA MENZIESII SERIES

The Intermountain Station collected data from eight habitat types of this series in the study area. Thirteen were recorded in the entire Gallatin and Beaverhead National Forests. Toward the eastern portion of the study area, the Douglas-fir types could be arranged on an altitudinal (low-high) and, to a lesser extent, moisture gradient as follows (dry-wet): Agropyron spicatum - Festuca idahoensis - Carex geyeri (uncommon) - Calamagrostis rubescens - Symphoricarpos albus - Physocarpus malvaceus - Vaccinium globulare. This was based on available Forest Service data, limited field checking, and information from Pfister et al. (1974). In the Gravelly Mountain area the Douglas-fir habitat types are apparently distributed in the following sequence: Agropyron

spicatum - Festuca idahoensis - Arnica cordifolia - Carex geyeri - Calamagrostis rubescens - Symphoricarpos albus. This distribution falls between that described for the Dillon-Lima area and that for the Madison-Beartooth Ranges provided by Pfister et al. (1974). (See appendix for illustrations.)

No field data were collected for these types. Since information was not available for understory species in most of the study area, some of the types in this series were often grouped. The Douglas-fir habitat types of Carex geyeri, Calamagrostis rubescens, and Festuca idahoensis were generally included together throughout the study area and were mapped as the Calamagrostis rubescens type. Arnica cordifolia was also included within this classification in the Gravelly Range and the Tobacco Root Mountain area. Attempts were made to separate the Symphoricarpos albus and Physocarpus malvaceus types, but the lack of data probably caused confusion. Vaccinium globulare could have been confused with these latter types in the eastern portion of the study area, as limited ground checking revealed that the presence of this species was listed inconsistently on range maps of the various areas. The possible confusion of types within this series should not cause problems when evaluating power line impact, since the ecology of these types is similar (see Table III). Because this system of vegetation classification is hierarchical, grouping of types has been suggested by Pfister et al. (1974) as being of value for some applications. Impacts of power lines on types not included in the type map but which may occur either rarely within or on the periphery of the study area are included in a following section.

c. PICEA SERIES

Picea habitat types occur commonly within the study area but we often grouped them with other forest types. This is because they are often found along streams in narrow bands less than the 80-acre minimum mapping unit used in this study. Bench areas also commonly support spruce, but timber type data were necessary to identify these areas. The Picea habitat types Equisetum arvense, Physocarpus malvaceus, Galium triflorum, Linnaea borealis, and Smilacina stellata were recorded within the study area by Pfister et al. (1974). Incidental field checking revealed the presence of Picea/Senecio streptanthifolius H.T. in the Gravelly mountains. According to Pfister et al. (1974), the Galium triflorum habitat type is most common in the wet bottom areas in the eastern portion of the study area, while various habitat types occur in the western portion. Most of the bench areas with deep soils between the Douglas-fir zone and subalpine fir zone also fell into this series. We had difficulty distinguishing the

spruce types without field data. There did not appear to be any clear trend as to the effect of exposure or altitude for most of these types. The Linnaea borealis type appeared to be confined to the northwesterly exposures. The types in this series were probably confused often and used interchangeably in the mapping procedure.

d. ABIES LASIOCARPA SERIES

The Abies lasiocarpa series occurred throughout the study area at elevations exceeding 7000 feet (occasionally lower). Excluding the subalpine habitat types, Pfister et al. (1974) recorded seven habitat types for this series in the study area. On the eastern portion of the study area they are distributed on an altitudinal gradient (low-high) and, to a lesser extent, on a moisture gradient (dry-wet) as follows: Calamagrostis rubescens - Linnaea borealis - Vaccinium globulare - Vaccinium scoparium. The Carex geyeri habitat type occurs in one small area in the Madison Range above 8000 feet but it apparently has limited distribution according to Pfister et al. (1974). Menziesia ferruginea habitat type also occurs, according to these authors, within the study area in the Madison Range near Yellowstone National Park. Its distribution is also limited in the study area. In the very moist bottom areas above the Picea/Galium triflorum habitat type the Abies lasiocarpa/Galium triflorum H.T. occurs. Where wet areas extend into higher elevations (approximately 7600 feet), this habitat becomes the Abies lasiocarpa/Calamagrostis canadensis habitat type. As these types are restricted to the narrow areas around streams, we often grouped them with other types.

In the eastern portion of the study area the subalpine fir series follows this altitudinal gradient (low-high): Calamagrostis rubescens - Vaccinium globulare - Arnica cordifolia - Vaccinium scoparium. The Linnaea borealis type is apparently rare and restricted to westerly slopes. The Clematis pseudoalpina habitat type appears in the western portion of the study area on calcareous substrates only, and was not identifiable without field checking. This distribution of habitat types in the Abies lasiocarpa series is between that described by Pfister et al. (1974) for the Beartooth-Madison Range and that described for the Dillon-Lima area, as was the case for the Douglas-fir series (see appendix for illustrations).

The most common type in this series is Vaccinium scoparium. In most areas this type was considered to be dominant and the smaller acreages of the Calamagrostis rubescens types were often grouped with it. Apparently the Arnica cordifolia

habitat type replaces Vaccinium scoparium on limestone substrates. The Vaccinium globulare H.T. was mapped in the lower areas of the Abies lasiocarpa series. The Linnaea borealis H.T., which is limited to the extreme northwestern slopes, was usually grouped with the Vaccinium scoparium or V. globulare types. In the western portion of the study area, the Arnica cordifolia H.T. is apparently more common, but lack of data on its distribution necessitated including it with the Vaccinium scoparium or the Calamagrostis rubescens types. The Galium triflorum H.T. was delineated only in the larger moist basins. Pfister et al. (1974) identified an Abies lasiocarpa/Alnus sinuata community type as occurring in the eastern portion of the study area. This community type was not identifiable with the methods used and was grouped with the Vaccinium scoparium H.T. in the mapping process.

The lower boundary of this series is 6800 feet, while the Douglas-fir series extends up to 7600 feet on the more open southerly exposures.

e. SUBALPINE HABITAT TYPES

Abies lasiocarpa extends up to the timber line in most areas as an associate with other species. The three subalpine habitat types that occur in the study area are distributed within the study area according to the following altitudinal gradient: Subalpine fir (white bark pine)/ Vaccinium scoparium H.T. - white bark pine/subalpine fir H.T. The subalpine fir (white bark pine)/Vaccinium scoparium H.T. is the most common and widespread type. The other types comprise small acreages adjacent to timberline and were often grouped with the latter type. Some areas in the Spanish Peaks of the Madison Range had more extensive acreages of the white bark pine/subalpine fir habitat type.

A subalpine fir/Ribes montigenum habitat type was described in the southern portion of the Gravelly Range but was determined to be a minor or incidental habitat type in Montana by Pfister et al. (1974). This type was not mapped in the study area.

f. PINUS CONTORTA SERIES

The lodgepole pine community presented problems in type determination. The types in this series have been established to cover areas where the climax species is not determinable because of very slow succession. Forest Service timber type data had extensive areas delineated as lodgepole pine with no

indication as to the climax species or reproduction within the stand. If adjacent stands indicated a climax series other than lodgepole pine, we assigned the lodgepole pine types to that series. These habitat types were usually Douglas-fir/*Calamagrostis rubescens* at lower elevations or subalpine fir/*Vaccinium scoparium* at higher elevations. The lodgepole pine stands that had no adjacent vegetation to reveal the climax species were delineated as lodgepole pine/*Calamagrostis rubescens* or *Vaccinium scoparium* habitat types, depending on elevation. Most lodgepole pine timber types were assigned to the Douglas-fir or subalpine fir series. The lodgepole pine/*Purshia tridentata* habitat type identified by Pfister *et al*. (1974) probably occurred in the portion of the study area near Yellowstone Park, but because of its small acreage we grouped it with other adjacent types of the Douglas-fir or subalpine fir series.

g. MISCELLANEOUS FOREST TYPES

Riparian communities and the aspen grove communities have not been classified by Pfister *et al*. (1974) as habitat types, although they are discussed by these authors. Aspen grovelands occurring commonly within the study area, particularly in the Gravelly Range, were identified as *Populus tremuloides*/*Pseudotsuga menziesii* community types. Many of the stands of this type appear to be successional stages of a *Pseudotsuga menziesii*/*Symphoricarpos albus* H.T. Some of the stands, however, may be self-perpetuating as described by Reed (1973). In one stand examined in the study area, the species *Spiraea betulifolia*, *Symphoricarpos albus*, and *Physocarpus malvaceus* were quite common. Other species recorded were *Erythronium grandiflorum*, *Fragaria* sp., *Rosa* sp., *Carex* sp., *Prunus virginiana*, *Clematis* sp., *Ribes* sp., *Amelanchier alnifolia*, *Trillium* sp., and *Thalictrum* sp. This area receives heavy deer and elk use in spring and winter.

Two riparian communities were also identified within the study area. These were separated on the basis of occurrence of *Populus tremuloides* or *Populus trichocarpa*. The data presented by Foote (1965) indicated little overlap between communities dominated by these species. The distribution of these species was correlated with organic content of the soil and degree of disturbance. *Populus tremuloides* communities were usually in smaller drainages and at higher altitudes. They often contained species of *Salix* and *Alnus*. The *Populus trichocarpa* communities are usually on flatter areas with deeper soils. *Pseudotsuga menziesii*, *Juniperus scopulorum*, and *Salix* sp. were usually associated with this

type. Succession in riparian communities is continaully being set back by frequent flooding.

Our data from one creek bottom in the study area indicated the following species associated with the *Populus tremuloides* type: *Salix* sp., *Rosa* sp., *Poa pratensis*, *Agropyron smithii*, *Bidens* sp. Although *Populus tremuloides* was rare or absent in some areas along the Ruby River, these areas were grouped with the *Populus tremuloides* type.

These areas are heavily grazed, as are most riparian communities throughout the study area. Widespread disturbance by livestock has left few if any riparian types in good condition for examination of "typal" communities.

Areas in the study area without significant vegetation due to earth movement or rocky aspect were identified as "scree" types. This term is used in a different context than used by Pfister *et al*. (1974) and include all rocky areas lacking vegetation. Some of them adjoin alpine areas and may provide escape habitat for mountain goats and bighorn sheep. They may also have aesthetic value.

D. Ecological Aspects of Vegetation Evaluated for Transmission Line Development Impact

We evaluated the following parameters with regard to the impact of development on vegetation: productive capacity for range and timber; a recovery rate after major disturbance and minor disturbance; suitability for wildlife; rarity in Montana. In addition, the species of greatest economic importance have been listed for each type, and the present vegetation conditions, aesthetic considerations, and presence of rare or endangered species are discussed.

Some of the parameters listed previously have been rated on a scale of 1 to 10 for each vegetation type. A rating of 1 indicates no adverse impact from power line development, while 10 indicates the greatest impact. The rationale for this rating system is discussed in the following sections for each parameter.

1. Productive Capacity

a. TIMBER

Timber productivity is the only parameter for which quantitative data were sufficient to allow direct assessment of the vegetation types. Pfister *et al*. (1974) listed the timber productivity of the various forest habitat types on the basis of cubic feet of wood per acre per year. This

productive capability was developed by using site indices and "stockability" factors for each of the habitat types. We used median timber productivity values for the forest types in Montana's southern and eastern National Forests to assess timber productivity potentials. Types that had the highest potential timber productivity were given high ratings on the 1-to-10 scale, and those with low potential productivity were assigned low ratings. The actual productivity ranges in cubic feet per acre per year and the numerical ratings are listed on Table III. All shrublands and grasslands were given ratings of 1 for this parameter.

b. RANGE

Productivity estimates for range were much more difficult to determine since little quantitative data were available. The forest habitat types were rated for range potential on the 1-to-10 scale. These ratings were based on the descriptions of potential productivity in Pfister _et al_. (1974), and the descriptions contained in the Forest Habitat types of the Deerlodge National Forest (U.S.F.S., 1974). These ratings are tentative and should be reevaluated when quantitative data become available for each habitat type.

Grazing capabilities of the shrub and grassland habitat types also are limited. Mueggler and Handl (1974) have listed increaser, decreaser, and invader species for each of their types, but productive capacity has not been included. The Soil Conservation Service (S.C.S.) generally rates carrying capacity of native range lands on the basis of soil rather than vegetation.[5] Payne (1974) has published a paper correlating ground cover with weight for a number of range species. We tried to determine the range productivity by converting Mueggler and Handl (1974) cover data to a weight basis, but were not successful because too many species occurred which were not listed by Payne. The shrub species, which often contribute to cattle browse, have received little study. Davis (1975) compiled a guide for determining potential herbage productivity at some central Montana range sites. The productivity values associated with the various range sites are listed in Table III. The productivity values assigned by Davis to the various range sites have been incorporated into our rating system. We also based the ratings on field observations of slope, exposure, elevation and moisture availability, made during the course of the study. The grassland habitat types were aligned from dry to wet as follows: _Stipa comata/Bouteloua gracilis_;

[5]Personal communication with Soil Conservation Service, Helena, Montana, June, 1975.

Agropyron spicatum/Bouteloua gracilis; Agropyron spicatum/Agropyron smithii; Agropyron spicatum/Poa sandbergii; Festuca idahoensis/Agropyron smithii; Festuca idahoensis/Agropyron spicatum; Festuca idahoensis/Deschampsia caespitosa. The Distichlis stricta/Agropyron smithii-Spartina community occurs in saline areas with high water tables. It apparently has higher productivity than adjacent dryland types. The Deschampsia caespitosum/Carex H.T. occurs in wet meadows and also is quite productive. Because of its small acreage it was not included as a mapping unit, but its productivity is compared with that of the other habitat types. Festuca idahoensis/Deschampsia caespitosum occurs only at higher elevations. Although it receives more moisture than the other types, the shorter growing season limits its productive potential. The other habitat types in the Festuca series were grouped with the Festuca idahoensis/Agropyron spicatum habitat type and were rated similarly to this type.

Range productivity information on shrublands is similar to that for grasslands. Extensive sagebrush control programs designed to increase rangeland productivity complicate rating many such vegetation types. Sagebrush control has been attacked in recent years (Daubenmire, 1970) for being undertaken without adequate investigation of ecological effects. The data of Davis (1975) was used when possible to evaluate these habitat types. Because of the competition with native grasslands, the shrublands have been rated slightly less productive than grasslands on similar soils, elevation and aspects. The moisture gradient of the types which we mapped is as follows (dry to wet): Rhus trilobata/Agropyron spicatum; Cercocarpus ledifolius/Agropyron spicatum; Artemisia arbuscula/Agropyron spicatum; Artemisia tridentata/Agropyron spicatum; Artemisia arbuscula/Festuca idahoensis; Artemisia tridentata/Festuca idahoensis. Other shrub types probably occur within the study area, but because they were not extensive enough to be used as mapping units were grouped with grassland types. These types are compared with the other vegetation types for future reference. Sarcobatus vermiculatus habitat types are similar in nature to the Distichlis stricta community type discussed previously, but produce less palatable forage. The two habitat types in this series were rated lower in productivity than the Distichlis stricta type for this reason, but above some of the drier types because of their high water tables.

The Juniperus scopulorum/Agropyron spicatum community type is apparently transitional between the limber pine forest types and the Rhus trilobata or the drier Festuca idahoensis habitat types, since it has vegetative components of both. Its range productivity was based on this observation.

Productivity of the riparian and aspen groveland types was rated rather high. Heavy grazing and browsing was observed in these types and high water tables apparently allow for high production of palatable grasses and browse species, although shade reduces browse and grass production on the sites with heavy canopies. The apparent moisture gradient of these types is as follows (dry to wet): Populus tremuloides/ Pseudotsuga menziesii community type, Populus tremuloides/ Alnus/Salix community type; Populus trichocarpa/Salix community type.

This system of evaluating productivity was based on field observations and the opinions of various authors who have studied range relationships. The results are summarized in Table III. Grass and shrublands were generally rated higher in productivity for range potential than forest lands as the palatable forage species did not have to compete with tree species for light and moisture.

2. Suitability for Wildlife

Wildlife ratings for the various forest habitat types were developed in a way similar to those for range productivity. The descriptions of the forest habitat types of Montana (Pfister et al., 1974) and the Deerlodge National Forest (U.S.F.S., 1974) were the basis for the ratings. Wildlife studies conducted within the study area were discussed earlier in the literature review.

Wildlife ratings for the shrub and grassland habitat types were based on the information in Table II and the available literature. These types were evaluated for each species of game animal present, and for the season or seasons of use (Table III). If a species is not listed, it does not necessarily mean that this type is not used by that species; in many cases the actual or potential suitability of the vegetation type could not be determined. Utah State University is now doing research that will relate the forest habitat types to wildlife usage.

3. Recovery Rates from Major Disturbance.

Major disturbance is defined in this report as the complete removal of the vegetation. This is the kind of impact associated with access road construction. The descriptions by Pfister et al. (1974) of the capacity of sites to be reforested were the basis for the ratings. The time required for reestablishment of tree species is the major criterion in this rating system. (Ratings were based on time required to reestablish an overstory of marketable trees, not time required to establish a climax forest.) Understory

and overstory recovery were considered together in the rating system, although understory recovery is much more rapid. Of course, rapid vegetation regrowth may not be the most desirable for transmission line maintenance after construction has been completed. Transmission line maintenance will probably be easiest where vegetation recovery is slow. Habitat types with slow tree reproduction may be preferable for transmission line maintenance. While this is important in rating the suitability of a vegetation type for a power line corridor, it should not take priority over the need for quick revegetation to prevent erosion.

Recovery rates for grassland and shrubland types present problems. First, little information for comparing recovery potential is available. Obviously, the return of land to a productive state takes much less time than return to a climax vegetation community. Also, the ability of land reclaimed after disturbance to withstand droughts and grazing pressure has not yet been determined. Because of the lack of information on this matter, recovery rates of shrub and grasslands were based on the moisture gradients listed in Section III. D. 1. b. and c. and on the information obtained from the literature review. The higher elevation habitat types were rated high (requiring long periods for recovery) because of the extremely short growing season. The susceptibility of alpine areas to disturbance has been discussed earlier. Rangeland types were rated as recovering faster than forest types for the following reasons:

1. Power line right-of-way maintenance usually involves continual removal of trees and tall shrubs.

2. Rangelands in the study area usually do not contain climax vegetation because of heavy grazing.

3. Establishment of climax vegetation on rangelands, although requiring long periods (more than 100 years on the drier types), will generally require less time than establishment of climax forest (hundreds of years in most cases). Establishment of climax vegetation on alpine areas requires extremely long periods.

Riparian communities and aspen groves were rated as being able to recover quicker than other forest types because of their favorable moisture conditions.

Disturbed areas, such as clearcuts and cultivated fields were rated low. The present level of disturbance is probably similar to that which will be encountered during transmission line construction, so recovery will not be a major factor. Timber production may be permanently terminated by the corridor maintenance; this should be considered when evaluating logged areas as possible corridor routes.

4. Recovery Rates from Moderate Disturbance.

Moderate disturbance is defined as that resulting from travel of heavy equipment during construction and from overstory removal for the corridor right-of-way. Habitat types on soils that are easily affected by vegetation removal, those on steep hillsides, and those containing dominant plant species known to be sensitive to disturbance were given high ratings. For the forest habitat types these ratings generally paralleled those for major disturbance. With grasslands and shrublands, recovery after heavy disturbance was often the reverse of that after moderate disturbance. Dry-land grasses appear to be more resistant to disturbance than those on moist sites. Idaho fescue is an exception; it appears to be more resistant to disturbances caused by grazing than is Agropyron spicatum, a species which occurs on drier sites. The shallow soils and short growing season of the alpine types makes their recovery slower despite abundant moisture. Grasslands and shrublands generally recover more quickly than forest land from moderate disturbance. The present vegetation on most of the study area consists of invaders or increasers that are able to recover more quickly from moderate disturbance than the climax vegetation. Grazing has altered the vegetation significantly in most areas. Power lines can be developed in many of these areas without access road construction or significant vegetation removal. The grasslands and shrublands are often on more gradual slopes than the forest areas. This should make them less susceptible to erosion if soils are similar.

Riparian types and aspen grovelands have been disturbed by wildlife and grazing. Because riparian vegetation stabilizes streambanks and controls erosion it is imperative that further disturbance there be limited. Consequently, these types were rated as highly sensitive to moderate disturbance. The aspen groveland ratings were similar to those for the other moist-site forest types. The ratings are listed on Table III.

5. Rare Vegetation Types.

Vegetation types usually change continuously from one geographical area to another. Thus, almost any habitat type is endemic in nature and is confined to a relatively small geographic area. Comparing the Montana habitat types of Pfister et al. (1974) and Mueggler and Handl (1974) with those developed by Daubenmire and Daubenmire (1968) and Daubenmire (1970) in Washington indicates that few of the types are found in both areas; usually some differences in species composition is apparent in types with similar names. Also, the rare types were often not included in the habitat types described by these authors because their systems were based on extensive data gathered over broad areas. As previously discussed in the literature review, rare habitats such as hot springs, bogs, and wet meadows, and climax grassland vegetation are probably the most endangered.

The vegetation types were rated on the basis of their abundance in the state; not in the study area. Climax communities, although not put in the rare category, should be considered valuable, particularly those in the grassland and shrubland types. The ratings for forest habitat types were based on the descriptions of Pfister _et_ _al_. (1974), while the grassland and shrubland ratings were based on our observations and the descriptions of Mueggler and Handl (1974).

Although rare vegetation types are usually more valuable to society, this is not always the case. Disease-carrying animals or exotic species are often considered undesirable although they may be rare. _Sarcobatus_ _vermiculatus_ is an uncommon vegetation type within the study area but it is undesirable for livestock and is considered less valuable than many other types.

6. _Present Condition of Vegetation_.

During mapping, the following measurements of present conditions of the vegetation were included: timber stocking and size class; range condition; agricultural development; and logging activity. Range conditions were evaluated only for field-checked areas. The data collected for the shrubland and grassland types are summarized on Table II. The grasslands and shrublands were rated as being in poor to fair condition; areas in good condition were rare. Abusive grazing practices, although not of the magnitude of earlier times, are still common. Field observations did not show any differences between private and public lands; grazing extremes occurred on both. Grazing condition was noted only for areas outside of the National Forest lands. Timber size and stocking were noted for all study area vegetation. The prime timber producing species and grass and browse species associated with each type were listed in Table III. Present vegetation condition was used in rating the recovery rates and susceptibility of the various types to disturbance. The value of the various habitat types to wildlife also depends on present conditions. Most wildlife species have suitable habitats on edge areas (ecotones) or areas in which successional species are common. Other factors, such as snow conditions and human activity, affect wildlife in many areas. Such factors were beyond the scope of our study, but should be considered when evaluating total transmission line impact.

7. _Aesthetic Considerations_.

We did not describe aesthetic values associated with the various habitat types. Aesthetic factors often are related to location and landform, rather than vegetation type. For example, rockslides have little vegetation but often have high aesthetic value. Maintaining native vegetation in a relatively undisturbed

condition should also be a major factor in any planning procedure that considers aesthetics (Pfister et al. 1971). Although aesthetics should be considered in power line siting, the ecological and economic value of the vegetation should receive top priority. For instance, Kitchings (1974) states "Placement of high voltage lines parallel to highways may be preferable, from an ecological standpoint, to screening by placing them behind an adjacent ridge, particularly if the area in question is a national forest or wildlife sanctuary." Thus, the vegetation values established by this report should outweigh the aesthetic consideration, wherever conflicts such as the above exist.

8. Rare and Endangered Species within the Study Area.

The problems encountered with listing rare and endangered species have been previously discussed (see literature review). The term "endangered species" as defined by Public Law 93-205, 93rd Congress, S. 1983, December 28, 1973, is as follows: "Any species which is endangered of extinction throughout all or a significant portion of its range." The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The report from the Smithsonian Institute (1975) discussed in the literature review lists species in the above classification. According to a local taxonomic expert[6] probably none of the species on this list is properly classified. An expanded list of plant species considered endangered by the Soil Conservation Service and comments of P. F. Stickney, a Forest Service botanist, is included in appendix C. This report stresses plants in the Helena National Forest, an area immediately north of the study area. Although this list reports rare plants that occur in Montana, they probably are not endangered or threatened.

Some habitats, however, are quite rare and have been affected over their range by man's activity. Micro-habitat sites within the study area such as bogs or hot springs should be protected because they usually have a unique flora and fauna. Fire protection may also eliminate seral vegetation habitats which have a flora favorable for wildlife.

Rare and endangered plant species were not evaluated on a vegetation mapping unit basis due to the lack of consensus as to which plants should receive this status and the general lack of information on their distribution.

[6]Personal communication with Klaus Lackschewitz, Bot. Dept., Univ. of Montana, Missoula, June, 1975.

IV. SUMMARY

We have attempted to review the pertinent literature on the impact of transmission line development on vegetation and to assemble current information on the study area vegetation. The second portion of this report has described the procedure we used in mapping the habitat types. Each of the mapping units has been described as to its relative position on a moisture-elevation gradient within the various sections of the study area. Each type has also been rated with reference to the impact of transmission line development on its ecology. The limitations of our methods are also described in this report and must be considered when referring to the vegetation map. We feel the advantages of the system outweigh the disadvantages. The habitat type system of vegetation classification is receiving more use and more data are being gathered, particularly for the forest types. This standardization of typing vegetation has the advantage of allowing a larger number of researchers to compare results from similar vegetation types. The grassland and shrubland habitat typing system needs refinement or replacement by a more workable system. Since the disturbances on these types of vegetation have been severe and widespread, a system of determining community types may be required to accurately map larger areas. Vegetation potential, in this case, may be more accurately determined using climatic conditions, soil types, exposure, slope and elevation, instead of the vegetation present on a particular site. In the case of grass and shrublands, a vegetation mapping system that considers both the potential vegetation and the present vegetation may be desirable. Our conclusions should provide a solid base from which to evaluate impacts of transmission line development on vegetation.

V. TABLES

TABLE I

Summary of aspect, elevation, and slope data for the study area forest habitat types from the Intermountain Range and Forest Experimental Station, Missoula, Montana

Total Number of Sites	Habitat or Community Type	Elevation Range	Elevation Mean	Slope Range	Slope Mean	Aspect Range	Aspect Mean*
Beaverhead and Deerlodge National Forests							
1	Psme/Arco	6550	6550	21	21	230	230
1	Psme/Feid	5750	5750	30	30	290	290
1	Psme/Phma	6290	6290	22	22	355	355
1	Psme/Vagl	6500	6500	14	14	340	340
5	Psme/Syal	6260-7550	6730	14-36	23	135-300**	244
5	Psme/Caru	6500-7700	6944	6-30	20	26-180	78
1	Psme/Cage	7650	7650	32	32	180	180
1	Picea/Eqar	6050	6050	1	1	90	90
1	Picea/Gatr	6140	6140	35	35	20	20
1	Picea/Libo	6600	6600	33	33	40	40
1	Picea/Smst	6600	6600	31	31	20	20
2	Abla/Libo	6900-7000	6950	3-16	10	210-350	280
3	Abla/Vagl	7000-7800	7367	6-18	12	10-310	42
3	Abla/Vasc	7800-8625	8332	5-12	8	0-325	29
3	Abla/Caru	7010-7700	7453	0-21	12	275- 0	340
1	Abla/Clps	8340	8340	18	18	245	245
12	Abla/Arco	7500-8350	7907	2-29	14	220-150	19
1	Abla/No fit	7200	7200	3	3	60	60
3	Abla-Pial/ Vasc	8250-8700	8433	5- 7	6	280- 0	358
2	Pial	8170-9200	8685	8-15	12	193-260	227

* Mean aspect determined by calculating mean unit vector.
** Ranges (left to right) read in a clockwise direction.

TABLE I
(continued)

Total Number of Sites	Habitat or Community Type	Elevation Range	Elevation Mean	Slope Range	Slope Mean	Aspect Range	Aspect Mean
Gallatin National Forest							
1	Pifl/Feid	6100	6100	23	23	000-170	170
1	Psme/Feid	7000	7000	26	26	180	180
1	Psme/Phma	5850	5850	32	32	102	102
1	Psme/Vagl	6200	6200	35	35	40	40
7	Psme/Syal	6150-7225	6832	20-35	29	126-295	218
5	Psme/Caru	5910-7600	7012	8-30	22	30-210	112
1	Psme/Cage	6450	6450	10	10	235	235
1	Psme/Agsp	5860	5860	35	35	165	165
1	Picea/Eqar	6830	6830	0	0	0	0
5	Picea/Phma	6000-7170	6394	7-34	18	85-275	169
5	Picea/Gatr	6000-7050	6736	0- 7	3	0-220	52
5	Picea/Libo	5700-7850	6486	8-29	18	2-320	284
1	Picea/Smst	6900	6900	20	20	296	296
10	Abla/Gatr	6350-7700	7053	1-26	17	13-323	152
3	Abla/Caca	7620-8800	8183	3- 9	6	45-360	359
4	Abla/Libo	6570-7550	7063	8-30	19	310-340	322
1	Abla/Mefe	7150	7150	40	40	360	360
5	Abla/Vagl	6900-8150	7505	14-28	22	22-155	101
4	Abla/Vasc	6840-8850	7860	6-23	13	82-315	175
3	Abla/Caru	7200-7700	7383	15-20	17	120-140	128
1	Abla/Cage	8550	8550	20	20	96	96
2	Abla/Alsi	6800-7700	7250	15-25	20	6- 50	28
9	Abla/Pial/ Vasc	8050-9340	8550	5-28	14	15-320	41
6	Pial/Abla	8650-9800	9395	14-37	26	80-360	325
1	Pial	9550	9550	0	0	190	190
1	Pico/Libo	7100	7100	30	30	260	260
3	Abla/No fit	7740-8600	8313	24-36	30	96-180	151
1	Psme/No fit	7600	7600	30	30	260	260

TABLE II

Summary of field data collected during this study for grassland and shrubland communities. Slope, altitude, aspect, range condition, and observed wildlife usage are recorded.

Total Number of Sites	Habitat or Community Type	Elevation Range	Elevation Mean	Slope Range	Slope Mean	Aspect Range	Aspect Mean*	Range Cond**	Range Wildlife***	
12	Stco/Bogr	4440-6600	4926	3-75	15	0-240****	170°	1.6	Antelope Deer	42% 8
21	Agsp/Bogr	4300-5800	5160	5-75	13	0-340	331°	1.6	Antelope Deer Elk	24 19 14
19	Agsp/Agsm	4200-5800	5016	0-50	13	70-360	68°	1.5	Moose Elk Deer Antelope	5 11 21 5
7	Agsp/Posa	5350-6000	5650	0-50	16	90-330	335°	2.3	Deer Antelope Elk	71 43 57
10	Feid/Agsm	4750-6600	5665	5-75	24	60-230	171°	2.1	Deer Elk	30 30
18	Feid/Agsp	4600-6200	5372	3-75	24	0-340	356°	1.8	Deer Elk	56 44
6	Arar/Agsp	4500-6000	5017	10-33	23	90-270	171°	1.3	Deer Antelope	16 33
1	Arar/Feid	6100	6100	30	30	45	45°	1	Deer	100
1	Artr/Agsp	5200	5200	20	20	340	340°	2	Deer Elk	100 100
4	Cele/Agsp	5200-5600	5400	20-25	28	0-330	260°	1.5	Deer	25
5	Rhtr/Agsp	4800-5600	5300	10-75	41	180-270	238°	1	Deer	20
1	Save/Agsm	4250	4250	3	3	225	225°	1	----	--
3	Jusc/	4500-4825	4675	8-35	19	290-310	300°	1.7	Deer	33
1	Anpo/Calo	5600	5600	18	18	160	160°	3	----	--
1	No Fit	5200	5200	3	3	135	135°	1	----	--

*Mean aspect determined by calculating mean unit vector.

**Range condition was rated as follows: 1-poor; 2-fair; 3-good. Mean value recorded.

***Wildlife values are recorded for each species as the percentage of the examined sites that wildlife sign or observations were recorded.

****Ranges (left to right) read in a clockwise direction.

TABLE III

POWERLINE DEVELOPMENT IMPACT

Comparative evaluation of the vegetative mapping units used in mapping the Dillon-Clyde Park Study Area.

Symbols used for mapping units, timber size and stocking classes, and range condition are included.

Mapping Unit Symbol	Habitat * or Community Type	Productive Capacity for: Forest **	Productive Capacity for: Range	Recovery Rates from: Major Disturbance	Recovery Rates from: Moderate Disturbance	Suitability for Wildlife: Species	Suitability for Wildlife: Season of Use	Rarity Type	Species of Prime Economic Importance
				FOREST HABITAT TYPES					
Pifl Series									
1	Pifl/Agsp	(5-15) 1 ***	2	10 Very low	10	Deer Elk	5 All seasons value as cover 3 Winter range and cover	7 Mod. rare	Agsp,Psme
2	Pifl/Feid	(5 -20) 1	3	9 Very low	9	Deer Elk	9 All season. High value as cover 10 Winter range and cover	7 Mod. rare	Assoc.Psme Feid,Agsp
3	Pifl/Juco	(10-20) 2	1	9 Very low	9	Deer	5 Summer and some winter	Rare or non-occurring in study area. Mod. rare in state 7	Psme
Psme Series									
4	Psme/Syor	This type was grouped with No. 11.							
5	Psme/Arco	(35-55) 5	4	8 Slow	8	Deer	6 Summer cover	7 Mod. rare but should be common in southwest portion of study area. Often combined with Psme/Caru (No. 12)	Psme

* See text for further description.

** Values listed in parenthesis are potential productivity range from Pfister *et al*. (1974) for forest types in southern and eastern Montana. Values are in cubic feet/acre/year.

*** All values are comparative rating reflecting impact of powerline development (1 = minimum impact; 10 = maximum impact).

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
6	Psme/Feid	(20-50) 3	6	8	8	Elk Deer	10 Winter range 10 Winter range. Summer range and cover.	6 Uncommon in state, common in study area.	Psme,Feid Agsp
7	Psme/Vaca	(55-80) 7	2	6	6	Elk Deer Moose	9 Winter range for all species	Common in state. Very rare or non-existing in study area 3	Psme,Amal big game browse
8	Psme/Phma	(45-80) 7	2	6 Steep slopes	6 Steep slopes and shallow soils	Elk Deer	3 Limited winter range for both species 5 Summer cover	2 Common in state, uncommon in study area	Psme,Amal, Prvi
9	Psme/Vagl	(50-70) 7	2	5	5	Elk Deer Bear	2 Spring and fall 9 Berry crop may be critical in eastern forests	7 Probably uncommon in state. Study area typical	Psme,Pico Vagl as re-creational resource
10	Psme/Libo	(50-100) 7 Western Montana	2	5	5	Elk Deer	3 Winter cover 5 Summer	7 Absent or very rare in study area. Widespread but small acreage statewide	Psme,Pico
11	Psme/Syal	(40-70) 7	2	7	7 Steep slopes common	Elk Deer Bl.grouse	8 Winter range for both species 6	3 Relatively common in study area and in state	Psme,Pico
12	Psme/Caru	(40-75) 7	4 Most produc-tive in a seral stage	8 Major scarifica-tion may be required for regeneration.	8 Poor recovery due to rhizomatous grasses and sedges competing with seedlings.	Deer Elk	6 Winter range Spring and fall	1 Most common type in study area and common in state. Type No. 11 was prob-ably grouped with this type frequently.	Psme,Pico

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for:		Recovery Rates from:		Suitability for Wildlife		Rarity Type	Species of Prime Economic Importance
		Forest	Range	Major Disturbance	Moderate Disturbance	Species	Season of Use		
13	Psme/Cage	(40-55) 5	3 Similar to No. 12 but drier.	9 Similar to No. 12 but drier	9 As above except drier	Deer Elk	3 Probably spring and fall use	5 Generally grouped with above type. Probably relatively common in study area	Psme
14	Psme/Aruv	(20-55) 4	5 No discussion of range potential	8	8 Very dry and steep slopes.	Deer Elk	7 Winter range	9 Rare in state. Probably non-occuring in study area	Psme(marg) Feid,Agsp
15	Psme/Juco	(40-60) 6	1	9	9 Steep and dry rocky slopes	Elk Deer	5 Summer range 3 Winter rare U.S.F.S. (1974) and Pfister et al.1974, disagree as to wildlife potential	6 Moderate in state. Rare or not occuring in study area.	Psme (marg) Juco, Juho as browse.
16	Psme/Agsp	(10-30) 2	6 May be somewhat limited by steepness of sites. Best in successional stages	8 Very slow timber growth	8 Poor soil development	Elk Deer Bl.grouse	10 Winter, fall and spring 9 All seasons. This type is heavily used at low elevations 9 Key blue grouse type	8 Rare in study area. Mod. rare in state.	Psme,Agsp, Amal,Putr
Picea Series									
17	Picea/Eqar	(70-100) 9	3 Variable	8 Water table and other wet site problems may hinder reclamation efforts	8 High water tables and poor drainage, streamside locations, and organic soils	Elk Deer R.grouse	5 Mod. winter use by all species. 5 Little summer deer cover 7 Probably important	10 Rare type in state and study area. Generally less than 80 acres.	Picea,Potr, Bepa,Salix

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Productive Capacity for: Range	Recovery Rates from: Major Disturbance	Recovery Rates from: Moderate Disturbance	Suitability for Wildlife: Species	Suitability for Wildlife: Season of Use	Rarity Type	Species of Prime Economic Importance
18	Picea/Phma	(70-110) 10	2	5	5	Elk Deer Moose	6 Seral stands may be moderate winter range	7 Uncommon in state but probably most abundant in Gallatin portion of study area; Often grouped with Type 19 or in Psme or Abla Series.	Psme, Picea Pico, Prvi, Phma, Amal
19	Picea/Gatr	(70-110) 10	2	5	5	Elk Deer Moose	7 Winter range at low elevations 10 All seasons	7 Common only in study area. Rare in most of state	Picea, Psme, Pico, Amal, Juco
20	Picea/Sest	(20-65) 6	1	8 Very low for spruce types	8 Poor moisture availability	-----	1 No significant wildlife potential	10 Minor type in state. May not occur in study area	Picea(marg)
21	Picea/Libo	(65-110) 10	4	8 Stream banks, poor soil types, high water tables affect tree reproduction	8 Stream bank and erosion possibilities	Elk Moose Deer	4 Summer 5 All seasons	6 Occurs widely but mainly in stringer stands along stream bottoms and N.E. slopes less than 80 acres	Psme, Picea, Pico
22	Picea/Smst	(60-110) 9	5 No information available	5 Deep fertile soils	5 May have erosion problems but should reestablish quickly	Moose	9 Year round high quality moose areas apparently	6 Occurs east of continental divide. May be grouped with No. 19 or 20.	Psme, Picea, Amal, Juco, Pico
Abla Series									
23	Abla/Gatr	(65-110) 10	8 May compete with big game	6 Stream banks and erosion may present problems	6 Highly productive but may have regeneration problesm. May be critical elk habitat	Elk Moose Sp.grouse	10 Summer-important wallow areas found here 6 All season 8 Use ecotonal edges	6 Most common in Gallatin area of study area	Picea, Abla, Pico, Psme

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Productive Capacity for: Range	Recovery Rates from: Major Disturbance	Recovery Rates from: Moderate Disturbance	Suitability for Wildlife: Species	Suitability for Wildlife: Season of Use	Rarity Type	Species of Prime Economic Importance
24	Abla/Vaca	(60-95) 9	4 Pfister _et al._ (1974) and USFS (1974) contradict	7 Pine grass may inhibit regeneration	7 Understory easily effected	Elk Deer	5 Summer 5 Summer	5 More common outside of study area	Pico, Abla, (minor)
25	Abla/Caca	(60-90) 8	9 May compete with big game	8 High water table may produce problems	8 Easily affected by heavy equipment because of high water table	Elk Moose	8 Summer 8 Summer	8 Widely distributed but of small acreages. Usually grouped with Type No. 23 or Type No. 30	Picea, Abla, Pico
26	Abla/Libo	(60-95) 9	7 All seral stages have palatable forage	8 Stream bank effects should be considered. Pico regeneration should not be difficult	8 Moist stream side areas may be easily affected	Elk Sp.grouse	6 Summer 7 Use at ecotonal areas	5 Relatively uncommon in study area. Often grouped with Types No.29 or 30. Common in state	Pico, Abla, Psme
27	Abla/Mefe	(70-90) 9	2	8 Brushfield formation may inhibit reproduction and steep slope sites may erode severely	8 Timber regeneration may be significant problem.	Elk Sp.grouse Moose	7 Range and cover 8 Use ecotonal areas 8 Season not listed, probably in spring and fall	5 Rare in study area; Common in state. Grouped with Type No. 30 usually, if it occurs at all.	Pico, Abla, Psme, Picea
28	Abla/Xete	(35-65) 5	1 Little value at any successional stage	9 May have problems with regeneration and erosion	9 Shallow soils and steep slopes make vulnerable to erosion	Elk Deer	3 Bear grass flowers utilized and may be used for escape cover	3 Most common of the Abla Series in the state. Rare or nonoccuring on study area	Psme, Pico, Abla

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
29	Abla/Vagl	(50-85) 8	3 Grazing may damage berry crop	7 Depends on slope. May be difficult on steep slopes	7 Berry crop may be adversely affected by moderate disturbance	Bl. Bear Gr. Bear Grouse	10 Summer. Fall berry crop may be critical factor in bear reproduction Use as food source	7 May be rather limited in state;most common in Gallatin.	Vagl,Abla, Pico,Psme
30	Abla/Vasc	(35-60) 5	2 Low	8 Lodgepole may establish easily but grows rather slowly. Abla or Picea establish with difficulty on drier sites.	8 Usually associated with highly erodable soils, occasionally even on moderate slopes.	Elk and Deer	7 Summer range and cover	1 One of the more common types found in its range and in western Montana. Types No.29 and 31 are often grouped with this type.	Pico,Abla
31	Abla/Caru	(65-95) 9	4 No information available. Assumed similar to Type No. 12.	6 May have trouble regenerating timber unless scarification is used or regeneration is maintained by careful logging techniques.	6 Apparently not as fragile as other Abla types	Deer and Elk	4 Some summer use. Little information available.	6 Not uncommon but grouped with Type No. 30 often.	Psme,Pico, Abla,Picea
32	Abla/Cage	(N.A.)	(N.A.)	----------	-----------	----	---------------	10 Occurs commonly in Idaho but very rare in Montana and was grouped with others in the Abla series if it occurred.	--------
33	Abla/Clps	(30-60) 4	4 Occasional use	9 Low recovery rate and easily erodable soils. Found only on limestone areas.	9 Shallow soils and steep slopes	Elk and Deer	5 Summer bedding areas	9 Quite rare and confined to limestone soils. May be locally abundant where conditions prevail.	Psme,Picea, Abla,Pico (all minor)

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
34	Abla/Arco	(65-95) 9	4 Little information. Probably is of some value	5 Apparently regenerates relatively easily.	5 Little information; Probably not high	Elk and Deer	5 Summer - moderate use	7 Occurs in study area but not widespread. Included with other Abla habitat types	Psme,Picea Alba,Pico
SUBALPINE HABITAT TYPE									
35	Abla/Rimo	No data 3 Probably low because of elevation and dryness	1 Little undergrowth in stands	10 High, dry, sites	10 Little vegetation and short growing season	Elk Deer	5 Summer 5 Summer	9 Very rare or non-occurring, but more common in adjacent southern states.	Abla (slight)
36	Abla (Pial)/ Vasc	(25-55) 4	3 Some forage but very sensitive to overuse. Highly competitive with wildlife	9 Poor regeneration, short growing season	9 Very high because of short growing season and shallow soils	Moose Deer Elk Bl. bear Gr. bear	8 Summer 8 Summer 9 Summer 10 10	8 Widespread but restricted to high altitudes	Pico,Picea (low)
37	Abla/Luhi	(20-50) 1	1 Little forage value	9 Short growing season	9 High probability of disturbance with cattle, etc.	Elk Bl.grouse	6 Summer 5	9 Rare or non-occurring in study area	None
38	Pial/Abla	(5-20) 1	1 Little forage value	10 Extremely slow	10 Very sensitive	Mtn.goats	10 All season	Restricted to timberline areas 10	None

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
39	Laly/Alba	Timberline 1	1 No forage	10 Short growing season	10 Very little soil development	Mtn.goats	8	9 Not in study but widespread in small acreages within state	None
40	Pial	Very slow growth 1	2 Easily damaged and of little forage value	10 Dry and high areas near timberline	10 Dry shallow soils	Gr.bear Mtn. goat Elk	10 Very important 9 6 Summer	10 Confined to timberlines. Grouped with Abla/Pial in mapping procedure.	None
Pico Series									
41	Pico/Putr H.T.	(40-50) 5	No information	6 Apparently reseeds quickly and Putr also is established after a period of time	6 Low growth rates but apparently establishes quickly	Moose Mule deer	9 All seasons 8 All seasons	9 Restricted to West Yellowstone area.	Pico,Putr
43	Pico/Vaca c.t.	(50-85) 7	2	6 Much longer to obtain climax of Douglas-fir or _Abies lasiocarpa_	6 Less susceptible than many forest types	Elk Deer Moose	8 May be winter range for all species; also spring-fall use	5 Common in state; rare or non-occurring in study area.	Pico,Amal at successional stages for browse
44	Pico/Libo c.t.	(55-75) 7	2	5	5	Elk Deer Moose	3 Light use in spring and fall for all species	6 Probably relatively common in study area but grouped with Type No. 12 or 30.	Pico
45	Pico/Vasc c.t.	(35-55) 5	2	7 May be difficult to establish	7 Often associated with erodable steep sites	Elk Deer Moose	7 Summer use	4 Common in eastern portion of state. Grouped with Type No. 30 in mapping process	Pico

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
46	Pico/Caru c.t.	(45-75) 7	4	8	8 Poor recovery of overstory removal	Deer and Elk	6 Winter - some spring and fall	2 Common in study area and in state. Often grouped with Type No. 12.	Pico
MISCELLANEOUS FOREST TYPES									
47	Potri c.t.	3 Good growth but of marginal value	9 Moist sites	3 Wet sites have quick regrowth	3 Stream bank stabilization and erosion problems are severe	White-tail Deer R. grouse	9 All Seasons 9	8 Widespread but small acreages.	Potri,Salix, Psme often occurs with this type
48	Potre/ Alnus/ Salix c.t.	(1) Little value	9	4	4 Stream bank and erosion affects may be severe	White-tail deer Mule deer Elk Moose	9 Winter and summer 6 6 10	8 Widespread but small acreages	Prvi,Salix as browse
49	Potre/Psme c.t.	(4)	8	5	5 May be on erodable sites	Deer Elk Moose	6 6 Winter 10	8 Widespread in study area but rare in state	Salix,Psme
50	Jusc/Agsp c.t.	(1)	6	8 Dry sites	8	Elk Deer	7 Winter 8 Summer	7 More common in eastern part of state	Agsp
Scree	Scree	1	1	1	1	Mtn.goat Bighorn sheep	10 All seasons as escape cover 8 All seasons - also may be important escape cover in some seasons	10 Aesthetic values may extremely out-weigh vegetative values	None

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range****	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
GRASSLAND HABITAT TYPES									
Stco Series									
60	Stco/Bogr	(1)	5 (165-823)	6	1	Antelope Deer	10 All seasons 2 All seasons	2	Stco,Bogr
Agsp Series									
61	Agsp/Bogr	(1)	6 (343-938)	5	4	Antelope Elk Deer	7 3 Winter 4	1	Agsp,Stco Bogr
62	Agsp/Agsm	(1)	9 (562-976)	3	5	Moose Elk Deer Antelope	2 3 Winter 5 2	1	Agsp,Agsm
63	Agsp/Posa	(1)	8 (No data)	4	4	Deer Antelope Elk	8 6 8 Winter	4	Agsp,Stco
64-65	Fesc Series (Not in study area)								
Feid Series									
66	Feid/Agsm	(1)	9 (523-1301)	1	3	Deer Elk	7 Winter 7 Winter	3	Feid,Agsm

****Values in paranthesis are productivity (air-dry pounds/acre) value ranges for grassland and shrubland habitat types (Davis, 1975).

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
67	Feid/Agsp	(1)	9 (510-1158)	2	2	Deer Elk	8 Winter range 8	1	Feid,Agsp
68-70	Other Feid Types grouped with Type No. 67								
71	Feid/Deca	(1)	8 (No data)	(9) High altitude areas including alpine included in this group	10 Shallow soils, short growing season	Mtn. goat Elk	7 8 Summer	9	Feid,Deca
Deca Series									
72	Deca/Carex	(1)	10 (No data)	5	5 Highly erodable areas and stream bank stabilization	(No direct Deer Elk	data available) 8 Summer 8	8 Occurs commonly but in small acreages within forest boundaries	Deca,Carex, various forbs
73	Elci Series (No data was obtained on this series but was observed to occur commonly on small acreages)								
SHRUBLAND HABITAT TYPES									
Arar Series									
74	Arar/Agsp	(1)	5 (No data)	4	4	Deer Antelope	5 8	6	Agsp,Stco
75	Arar/Feid	(1)	7 (No data)	2	5	Deer	5 Winter	9 Uncommon	Feid,Agsp

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for: Forest	Range	Recovery Rates from: Major Disturbance	Moderate Disturbance	Suitability for Wildlife: Species	Season of Use	Rarity Type	Species of Prime Economic Importance
Artr Series									
76	Artr/Agsp	(1)	6 (685-912)	4	4	Deer Elk Antelope	8 Winter 8 Winter 10	2 Grouped usually with Agsp series	Agsp,Stco
77	Artr/Fesc	Does not occur in study area. No data available.							
78	Artr/Feid	(1)	9 (623-1371)	2	5	Deer Elk	8 Winter range 8	1 Most sites were thought to be disturbed Type No. 67.	Feid,Agsp
Artri Series									
79	Artri/ Feid	(1)	7 (No data)	2	5	Elk Deer	8 8 Winter range	1 Occurred in western portion of study. Probably successional stage of Type No. 67	Feid,Agsp
80	Arpe Series (This series was not found in the study area)								
	Pofr Series (Apparently the Feid habitat type in this series occurred on Forest Service lands in small acreages but was not mapped as individual types in this procedure)								
83-85	Putr Series (This series probably occurred on small acreages but was not typed during this study)								
Cele Series									
86	Cele/Agsp	(1)	6 (No data)	5	9 Steep rocky slopes	Elk Deer Mtn. goat	9 Winter 10 All seasons 10 Winter	8 Only on steep slopes in southwestern Montana	Cele,Agsp Browse and grass

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for:		Recovery Rates from:		Suitability for Wildlife		Rarity Type	Species of Prime Economic Importance
		Forest	Range	Major Disturbance	Moderate Disturbance	Species	Season of Use		
Rhtr Series									
87	Rhtr/Agsp	(1)	6 (No data)	5	3	Deer	8 Winter	5 Widespread but confined to steeper slopes.	Agsp,Stco
88	Rhtr/Feid	(Did not occur in study area)							
Save Series									
89	Save/Agsm	(1)	6 (No data)	1	2	Deer and Antelope	3	9 Uncommon in study	Agsm, Save has browse value in certain areas
90	Save/Elci	(1)	6 (No data)	1	2	Deer and Antelope	3	9 Smaller acreages than Type No. 89 with which it was grouped.	Elci,Save
INCIDENTAL GRASSLAND TYPES									
91	Dist c.t.	(1)	5	1	1	Waterfowl nesting	8	10 Occurs in saline basins only	Agsm
92	Ansc c.t.	(1)	7	4	5 Shallow soils; much more common in eastern Montana	Deer	3 Summer	10 Rare in study area	Ansc,Calo

Mapping Unit Symbol	Habitat or Community Type	Productive Capacity for:		Recovery Rates from:		Suitability for Wildlife		Rarity Type	Species of Prime Economic Importance
		Forest	Range	Major Disturbance	Moderate Disturbance	Species	Season of Use		
A	Altered (includes all non-forested lands that have had the native vegetation disturbed by means other than grazing)	(1)	1 Variable but not significantly affected by power line development. If this land is to be taken out of production it should be rated quite high, as it is quite productive.	1 Assumes top soil remains intact	5 Rated higher because of damage to crops for one season may be significant	Variable	------------	1	Variable
CC	Clear cuts	(5) Variable but power line development may eliminate timber productivity on much of right-of-way	5 Variable, but probably higher than adjacent forest types because of overstory removal	5 Variable	5 Usually roaded and already moderately disturbed	Deer Elk	5 Depends on size, altitude and location. Both beneficial and harmful potential	1	Variable- Browse species or grass for livestock or wildlife
SC	Selective Cuts	Evaluated	the same as Clear cuts						

KEY TO OTHER SYMBOLS UTILIZED IN MAPPING

Symbol	Description
Timber size and stocking	
A	More than 9" d.b.h., stocking greater than 40%
B	More than 9: d.b.h., stocking less than 40%
C	Less than 9" d.b.h., stocking greater than 40%
D	Less than 9" d.b.h., stocking less than 40%
Range condition (subjective field estimates)	
P	Poor
F	Fair
G	Good

VI. APPENDIX

A. List of Scientific Names, Common Names and Abbreviations of Plant Species used in this Report.

B. Current and Recent Research on Biological Effects of High Voltage Transmission.

C. Documentation on Rare and Endangered Species of Plants in Montana.

D. Distribution of Habitat Types in the Dillon-Lima Vicinity and Madison to Beartooth Ranges.
(Reproduced from Pfister *et al.*, 1974)

A. SCIENTIFIC, COMMON NAMES AND ABBREVIATIONS OF PLANT SPECIES USED IN TEXT

Scientific Name	Common Name	Abbreviation
Trees		
Abies lasiocarpa	Subalpine fir	Abla
Betula papyrifera	Paper birch	Bepa
Larix lyallii	Alpine larch	Laly
Picea engelmannii	Engelmann spruce	Picea or Pien
Picea glauca	White spruce	Picea or Pigl
Pinus albicaulis	Whitebark pine	Pial
Pinus contorta	Lodgepole pine	Pico
Pinus flexilis	Limber pine	Pifl
Pinus ponderosa	Ponderosa pine	Pipo
Populus tremuloides	Quaking aspen	Potre
Populus trichocarpa	Black cottonwood	Potri
Pseudotsuga menziesii	Douglas fir	Psme
Shrubs		
Alnus sinuata	Alder	Alsi
Amelanchier alnifolia	Serviceberry	Amal
Arctostaphylos uva-ursi	Kinnikinnik	Aruv
Artemisia arbuscula	Black sage	Arar
Artemisia cana	Silver sage	Arca
Artemisia pedatifida	Birdfoot sage	Arpe
Artemisia tridentata	Big sage	Artr
Artemisia tripartita	Threetip sage	Artri
Berberis repens	Oregongrape	Bere
Cercocarpus ledifolius	Mt.-mahogany	Cele
Chrysothamnus nauseosus	Rubber rabbit-brush	Chna
Gutierrezia sarothrae	Broom snakeweed	Gusa
Juniperus communis	Common juniper	Juco
Juniperus horizontalis	Creeping juniper	Juho
Juniperus scopulorum	Rocky Mt. juniper	Jusc
Linnaea borealis	Twinflower	Libo
Menziesia ferruginea	Menziesia	Mefe
Potentilla fruticosa	Shrubby cinquefoil	Pofr
Physocarpus malvaceus	Ninebark	Phma
Prunus virginiana	Chokecherry	Prvi
Purshia tridentata	Bitterbrush	Putr
Rhus trilobata	Skunkbush sumac	Rhtr
Ribes montigenum	Alpine prickly currant	Rimo
Rosa sp.	Rose	Rose
Salix sp.	Willow	Salix
Sarcobatus vermiculatus	Black greasewood	Save
Shepherdia canadensis	Buffaloberry	Shca

Scientific Name	Common Name	Abbreviation
Spiraea betulifolia	White spiraea	Spbe
Symphoricarpos albus	Snowberry	Syal
Symphoricarpos oreophilus	Mt. snowberry	Syor
Vaccinium caespitosum	Dwarf huckleberry	Vaca
Vaccinium globulare	Blue huckleberry	Vagl
Vaccinium scoparium	Grouse whortleberry	Vasc
Grasses		
Agropyron caninum	Bearded wheatgrass	Agca
Agropyron dasytachyum	Thickspiked wheatgrass	Agda
Agropyron smithii	Western wheatgrass	Agsm
Agropyron spicatum	Bluebunch wheatgrass	Agsp
Andropogon scoparius	Little bluestem	Ansc
Bouteloua gracilis	Blue grama	Bogr
Calamagrostis canadensis	Bluejoint reedgrass	Caca
Calamagrostis rubescens	Pine grass	Caru
Calamovilfa longifolia	Prairie sandreed	Calo
Carex filifolia	Threadleaf sedge	Cafi
Carex geyeri	Elk sedge	Cage
Carex sp.	Sedge	Carex
Deschampsia cespitosa	Tufted hairgrass	Deca or Dece
Distichlis stricta	Alkalai saltgrass	Dist
Elymus cinereus	Giant wildrye	Elci
Festuca idahoensis	Idaho fescue	Feid
Festuca scabrella	Rough fescue	Fesc
Luzula hitchcockii	Smooth woodrush	Luhi
Oryzopsis hymenoides	Ricegrass	Orhy
Poa pratensis	Kentucky bluegrass	Popr
Poa sandbergii (secunda)	Sandberg's bluegrass	Posa
Spartina gracilis	Alkalai cordgrass	Spgr
Stipa comata	Needle-and-thread	Stco
Stipa richardsonii	Richardson's needlegrass	Stri
Forbes, etc.		
Arnica cordifolia	Heartleaf arnica	Arco
Artemisia frigida	Fringed sagewort	Arfr
Balsamorhiza sagittata	Arrowleaf balsamroot	Basa
Clematis pseudoalpina	Rocky Mt. clematis	Clps
Equisetum arvense	Horsetail	Eqar
Galium triflorum	Sweet bedstraw	Gatr
Opuntia polyacantha	Prickly pear	Oppo
Senecio streptanthifolius	Cleft-leaf groundsel	Sest
Smilacina stellata	Starry solomon's seal	Smst
Xerophyllum tenax	Bear grass	Xete

B. CURRENT AND RECENT RESEARCH ON BIOLOGICAL EFFECTS OF HIGH VOLTAGE TRANSMISSION

EPRI - IIT Research Institute (RP 381)

A contract to outline a long-range program for EPRI (Electric Power Research Institute) study into the effects of electric fields on the environment. Study being coordinated by the Energy Systems Environment and the Conservation Division of EPRI.

EPRI - Westinghouse-Penn State (RP 129)

A research contract to study gross effects of high stress electric fields on plant germination and growth. Also will study effects on animals and soils. Long-term studies will be carried out at Waltz Mill at a special ecological experiment laboratory.

EPRI - Power Technologies (RP 260)

A contract related to improved utilization efficiency of overhead rights-of-way. Began in May 1974. The study will investigate field effects on song birds, mice, rabbits, and turkeys.

EPRI - John Hopkins (RP 98)

A contract dealing with field effects on animal tissues at the cellular level. Has been in progress since 1970. Principal investigator Dr. W.B. Kouwenhoven. Specific areas of research include chromosomal studies, exposure of beating heart cells, metabolic effects and cancer cell reaction.

Northeast Utilities - U. of West Virginia

Deals with the effect of electric fields on vegetation and wildlife. Dr. Kenneth Carvell is the principal investigator.

U.S. Department of Navy - Aerospace Medical Research Laboratory

Studying the effect of low-frequency electromagnetic fields on the behavioral functions of monkeys. Monkeys will be observed performing learned behavioral functions under the influence of low-level electric and magnetic fields. Project to extend over three years.

U.S. Department of Navy - Aerospace Medical Research Laboratory

Exposure of human volunteers to controlled exposure of electric and magnetic fields. Laboratory tests will progress in stages starting with short-term exposure of lower primates and then man, progressing to several months' exposure. Tests will be made to study metabolic effects, automatic nervous system response and central nervous system performance. Principle investigators: D.E. Beischer and J.D. Grissett.

U.S. Veterans Administration

Effect of magnetic fields on monkeys. Some work on humans. Primarily d-c fields, however, modulated d-c fields (0.2 Hz) are also studied (5-11 Gauss). Principal investigator: Dr. H. Friedman.

U.S. Department of Agriculture - Virginia Polytechnic Inst.

Studying the effect of magnetic and electrostatic fields on behavior of insects (cabbage moth). Areas of study will include respiration processes, life expectancy, egg production, and reproduction.

State of Wisconsin - U. of Wisconsin

Studying effects of electric fields (45 hZ, 10V/M) on plant and microbial metabolism. Principal investigator: W.R. Gardner, Dept. of Soil Science.

AEP ASEA UHV Research Project

Research Facility: American Electric Power Service Corp; Ohio Brass Frank B. Black Research Center; ASEA Mgf. Co.; Hydro-Quebec IREQ Lab. American Electric Power Service Corp., 2 Broadway, New York, New York 10004. Investigator(s): Barnes, H.C. Sponsor(s): American Electric Power Service Corp.: ASEA; Ohio Brass Co.; Hydro-Quebec. Duration: January 1969-1978. Funding: Proprietary Description: Objective of the research is to establish practical limits of ultra-high voltage for the transmission of electric power.

Indiana and Michigan Electric Company and Others

Research Facility: American Electric Power Service Corp., 2 Broadway, New York, New York 10004. Investigator(s): Scherer, H.N., Jr. Sponsor(s): Indiana & Michigan Electric Co.; Ohio Power Co.; Kentucky Power Co.; Appalachian Power Co. Duration: 1965 to 1976. Funding: Proprietary. Environmental effects of 765-kV transmission under all types of weather conditions; radio and television influence; ozone production, if any; and induced voltage effects are all being researched in order to confirm basic knowledge considered in the initial design.

Hawaiian Electric Co., Inc.

Title: Review of the Ecological Influence of High Intensity Electric Fields. Research Facility: Hawaiian Electric Co., Inc. Atten: E.A. Helbush, 900 Richards St., Honolulu, Hawaii 96813. Sponsor(s): Hawaiian Electric Co., Inc. Duration: 1973. Description: To review existing literature and query other utilities to see what the status is currently concerning the effects of high intensity electric fields on people, animals, plants, and soils. Location: Hawaii.

American Electric Power Service Corporation

Title: EHV and UHV Transmission Lines and Audible Noise Research Facility: Massachusetts Institute of Technology, Cambridge, Mass. 02139. Investigator(s): Wilson, G.L. Sponsor(s): American Electric Power Service Corp. Duration: September, 1967, through August, 1974. Funding: Proprietary. Description: The purpose of this project is to quantify the sources of acoustic noise eminating from EHV and UHV transmission lines.

Tennessee Valley Authority

Title: Causes and Characteristics of Sounds Produced by Transformers and Reactors. Research Facility: Tennessee Valley Authority, Div. of Transmission Planning and Engineering. Chattanooga Bank Bldg.; Chattanooga, Tennessee 37402. Investigator(s): St. Clair, B.C. Sponsor(s): Tennessee Valley Authority. Duration: 1973 to Indefinite. Funding: 1974 - $5,000. Description: An investigation of the causes and characteristics of sounds produced by transformers and reactors.

EPRI - Project UHV (RP 68)

Title: UHV Transmission (Project RP 68)
Research Facility: General Electric Co.; 100 Woodlawn Avenue; Pittsfield, Mass. 01201. Investigator(s): Zaffanella, L.E. Sponsor(s): Edison Electric Institute; Electric Power Research Institute; U.S. Dept. of Interior, Bonneville Power Administration; Tennessee Valley Authority; American Public Power Association.

Duration: January 1965 through December, 1976. Funding: Proprietary. Description: Project UHV has supplied much of the data necessary for the preliminary design of UHV transmission systems. Environmental work includes: (1) Consideration of methods to reduce the audible-noise levels that occur on UHV lines in wet weather (2) Contamination flashover performance of long insulator strings, and correlations of flashover performance characteristics with the requirements of lower voltage lines (3) Further development of the theoretical concepts involved in the study of wet weather radio and audible noise, corona loss, drop formation on conductors, and flashover of contaminated surfaces in fog (4) Evaluation of the effects of charging currents of UHV lines and study of ozone and nitrous oxide generation. Location: Massachusetts.

C. DOCUMENTATION ON RARE AND ENDANGERED SPECIES OF PLANTS IN MONTANA

INTRODUCTION

The policy of the Forest Service is to give special emphasis to the protection of rare and endangered plants. No list, however, has ever been compiled of such plants for the Northern Region of the Forest Service, which includes northeastern Washington, northern Idaho, Montana, North Dakota and the northwest corner of South Dakota.

This is an initial listing of plant species considered uncommon, rare, or endangered for this Region. The list was developed after consultation and correspondence with taxonomists, ecologists, botanists, range managers, foresters, and wildlife biologists in universities, colleges, other state and Federal agencies, and the Forest Service. We appreciate and wish to acknowledge their help and suggestions.

Classification of species as rare, endangered, or uncommon was often difficult. We considered as rare those species a person familiar with vegetation would not expect to see on a casual trip or to find without a special effort. Frequently, species are rare in the Northern Region simply because suitable habitat is scarce or the Region happens to be on the periphery of their ranges. Uncommon species are intermediate in occurrence and abundance, between rare and common species in the Northern Region.

The greatest threats to the existence of rare and uncommon plants are: 1)thoughtless and indiscriminate collecting of species with drug or medicinal properties; 2) collecting for use as ornamentals and 3) modification of the habitat through resource management or land development. We hope this list will bring an awareness of those plants which are rare or endangered and in need of protection.

We recognize the list is by no means complete, and that some species have not been correctly classified. Any comments, suggestions for improvement, or additions to the list will be welcomed.

RARE PLANTS FOUND IN THE NORTHERN REGION

I. Ferns, Mosses, and Fungi

Adiantum pedatum - Maidenhair fern. Dripping cliffs, seeps and moist woods in the Thuja-Tsuga zone.

Asplenium trichomanes - Maidenhair spleenwort. Cliff crevices and talus slopes. Rare at least in eastern Washington.

Blechnum spicant - Deer fern. Moist or wet (often dense) woods. Probably restricted to areas above the North Fork of the Clearwater in northern Idaho.

Botrychium spp. - Grape fern. Moist or wet places. usually restricted to undisturbed sites in the Tsuga-Thuja zone.

Dryopteris arguta - Shield fern. Wooded areas often fairly dry. Collected beneath Thuja plicata or Tsuga mertensiana climax stands on the North Fork of the Clearwater in Idaho.

Lycopodium inundatum var. inundatum - Clubmoss. Mostly in sphagnum bogs. Rare at least in north Idaho. Known from a bog adjacent to the Bismark Trail in Boundary County.

Lycopodium _selago_ - Clubmoss. Moist areas on exposed cliffs and talus slopes to stream banks and dense woods, usually in _Thuja_ _plicata_ climax areas. Collected near Hope, Idaho. Found on the North Fork of the Clearwater and Lochsa Rivers in Idaho.

Lycopodium _sitchense_ - Clubmoss. Moist areas, frequently rocky places, often above timberline. Collected near Bunchgrass Meadows in northeastern Washington. Reported above the Lochsa-Selway area.

Pityrogramma _triangularis_ - Goldback fern. Rock crevices and open, rocky slopes. Rare if even present in R-1. The only known location east of the Cascades is at Granite Rocks on the Snake River upstream from Wawawai.

Polypodium _hesperium_ - Licorice fern. Moist areas, less often on ordinary soil in the woods, from the lowlands to well up in the mountains. Possibly restricted to red alder sites as on the lower Lochsa River in Idaho.

Polyporus _ellisii_ -
This fungus is reported on the North Fork of the Clearwater River in Idaho.

Polystichum _mohrioides_ -
Open rocky slopes below timberline. Rare in Idaho and range is uncertain.

Polystichum munitum var. imbricans - Holly fern. Rock crevices and rocky soil in dry coniferous forests. Reported in Idaho.

Selaginella douglasii - Little clubmoss. Shady areas. Reported on the lower Lochsa and main Clearwater Rivers in Idaho.

Sphagnum riparium - Bogs and other wet areas. Collected only in Bunchgrass Meadows in eastern Washington which are being considered for impoundment.

II. Grasses and Grasslike

Carex hendersonii - Henderson sedge. Wet places at low elevations in climax Thuja stands. Found on lower Lochsa and North Fork of the Clearwater in Idaho.

Hierochloe odorata - Sweetgrass. Moist soil of lower montane to subalpine meadows and slopes, known from one station near Townsend, Montana, and probably found in Sweetgrass Hills of North Central Montana.

Juncus covillei - Coville rush. Wet places, particularly around lakes. Known only from one collection near Elk River.

Juncus effusus var. _pacificus_ - Common rush. Streambank in _Thuja plicata_ zone on the North Fork of the Clearwater in Idaho.

Leersia oryzoides - Rice cutgrass. Wet places, often in 10-15 inches of water. In Montana known only from Lolo Hot Springs area, Missoula County.

Scirpus cespitosus - Deerhair bulrush. Bogs, marshes, and other wet places.

Scirpus hudsonianus - Bogs and other very wet places.

Scolochloa festucacea - Sprangletop. Marshes and edges of lakes or streams.

Trisetum orthochaetum - No common name. Boggy meadow. Known only from one collection near Lolo Hot Springs, Missoula County, Montana.

III. Forbs

Allium bisceptrum - Twincrest onion. Moist soils on the lower Selway and Middle North Fork of the Clearwater in Idaho.

Artemisia douglasiana - Cudweed. Streambanks and river bottoms along Coeur d'Alene Lake and the North Fork of the Clearwater in Idaho.

Asarum canadense - Wild ginger. Rich woods. Known only from eastern North Dakota in Region 1.

Aster jessicae - Jessica aster. Streambanks and open places. Found near Pullman, Washington and on American Ridge, Latah County, Idaho.

Aster subspicatus - Streambanks and moist woodlands. Rare in north Idaho and western Montana.

Bolandra oregana - Oregon bolandra. Moist, mossy rocks, usually near waterfalls. Found on lower Lochsa.

Boykinia major var. intermedia - Large boykinia. Meadows and along streams. Found on lower Lochsa beneath red alder.

Calochortus elegans var. selwayensis - Cat's ears. Grassy hillsides and open coniferous woods. Higher elevations of the Bitterroot Mountains of Idaho with some extension into western Montana.

Calypso bulbosa - Fairy slipper. Mostly in deep shade of cool, moist forests, in soil rich with decaying leaves and wood.

Collomia heterophylla - Woods, forest openings and loose streambanks. Collected on a disturbed road bank, Thuja zone, North Fork of the Clearwater in Idaho.

Corallorhiza spp. - Coral root. Moist to fairly dry woods.

Corydalis caseana var. hastata - Idaho fitweed. Wet places, usually along streams in the lower Lochsa-Selway area.

Cypripedium spp. - Lady slipper. Dry to usually moist woods.

Dasynotus daubenmirei - Forest openings at moderate to high elevations in the mountains. Known only near Walde Mountain Lookout north of Lowell, Idaho.

Dodecatheon dentatum - Dentate shooting star. Around waterfalls, streambanks and shaded, moist slopes. Found along the North Fork of the Clearwater and Coeur d'Alene Rivers in Idaho.

Eburophyton austiniae - Ghost orchid. Moist dense woods. Found beneath nearly mature stands of Thuja plicata and Abies grandis on the lower Lochsa in Idaho.

Epipactis gigantea - Giant helleborine. Wet areas especially near thermal waters. Probably restricted to the western part of the Region.

Equisetum telmateia - Giant horsetail. Moist low places, usually below Thuja plicata climax stands. Found in Idaho on the North Fork of the Clearwater, Lochsa-Selway and one station on the main Clearwater River. Most of the habitat will be flooded by Dvorshak Dam.

Grindelia howellii - Known only from the bluffs above the St. Maries River in Idaho.

Ivesia tweedyi - Ivesia. Dry, usually rocky, open to wooded slopes or alpine ridges. Known in Coeur d'Alene Mountains of Idaho.

Lathyrus bijugatus - Drypark peavine. Lower foothills, in open parks or under trees. Extreme eastern Washington and adjacent Idaho. Also reported from Montana but record is questionable.

Lilium spp. - Lily. Meadows and prairies to forested areas.

Mertensia bella - Bluebell. Moist areas at middle elevations in the mountains. Subalpine above the Lochsa-Selway area in Idaho.

Maianthemum dilatatum - False lily-of-the-valley. Moist areas in open to dense woods. Collected from a cedar swamp on the east side of Priest Lake in Idaho.

Phlox idahonis -
Moist meadows and streambanks. Known only near Headquarters and Pierce, Idaho.

Psoralea physodes - California tea. Logged-off land. One station reported near Troy, Idaho.

Sanicula marilandica - Black sanicle. Moist low ground, less often on moist wooded slopes. Found in the western part of Region 1.

Sanguinaria canadensis - Bloodroot. Found in the woods along the Red River and some of its tributaries in North Dakota.

Satureja douglasii - Savory. _Tsuga heterophylla_ - _Pachistima myrsinites_ habitat type. Probably restricted to northern Idaho.

Stanleya pinnata - Desert prince's pine. Plains to the lower mountains. Rare in North Dakota where it has been recorded only on clay buttes in Billings County. More common to the south and west.

Streptopus streptopoides
Dense, coniferous, midmontane woods. Probably restricted to north Idaho and northeastern Washington.

Synthyris platycarpa - Selway synthyris. Open woods. Reported along the Selway River in Idaho.

Tofieldia glutinosa var. *absona* - Tofieldia. Meadows, bogs and streambanks to alpine ridges. Known only from Priest Lake area in Idaho.

Veratrum californicum var. *caudatum*
Wet areas from lowlands to subalpine. Found above the North Fork of the Clearwater and Lochsa-Selway Rivers in Idaho.

Veronica wormskjoldii - American alpine speedwell. Moist areas at moderate to high elevations in the mountains.

Viola sempervirens - Evergreen violet. Moist woods, mostly beneath near climax Thuja plicata. Reported on the North Fork of the Clearwater in Idaho.

Waldsteinia idahoensis - Barren strawberry. Reported only for lower Lochsa River in Idaho. Meadows along streams.

IV. Shrubs and Trees

Berberis aquifolium - Oregon grape. Woods to sagebrush slopes. Rare in extreme southwestern North Dakota. More common in the western part of the Region.

Berberis nervosa - Oregon grape. Moist protected ravines in northeastern Washington and northern Idaho. Also in Thuja-Tsuga zone on the upper Palouse River and around Coeur d'Alene Lake.

Cornus nuttallii - Pacific dogwood. Along streams and in open to fairly dense forests. Found along the Middle Fork of the Lochsa in a Thuja plicata - Adiantum pedatum vegetation type.

Physocarpus capitatus - Pacific ninebark. Moist areas in the *Thuja plicata* climax. Reported on the Lochsa-Selway and North Fork of the Clearwater Rivers.

Pinus flexilis - Limber pine. Rare in North Dakota. Found only in the Little Missouri valley. More common in the western part of the Region.

Ribes howellii
Streamsides and moist places in the *Thuja*-*Tsuga* zone. Reported above Priest Lake in Idaho.

Vaccinium oxycoccos - Wild cranberry. Usually in sphagnum bogs. Reported in northeastern Washington and northern Idaho.

Viburnum edule - Mooseberry viburnum. Moist woods and swamps. Collected on Slate Creek in northeastern Washington.

Viburnum opulus - High-bush cranberry. Moist woods. Collected on the flood plain at Tiger Slough in northeastern Washington.

UNCOMMON PLANTS FOUND IN THE NORTHERN REGION

I. Ferns, Mosses and Fungi

Lycopodium spp. - Clubmoss. Moist coniferous woods in the western part of Region 1. All species are uncommon and some are rare.

Pellaea spp. - Cliff-brake. Rocky places from the foothills to timberline.

II. Grasses and Grasslike

Festuca scabrella - Rough fescue. Grasslands to open montane slopes. Uncommon in North Dakota and eastern Montana. Common in the western part of the Region, on suitable habitat.

Hesperochloa kingii - Spike fescue. Usually on dry grasslands, rolling hills or higher ridges. Known on the Gravelly Range in southwestern Montana, and on the Custer National Forest.

III. Forbs

Aquilegia canadensis - Columbine. Moist woods of North Dakota from the Red River Valley to the Turtle Mountain area.

Calachortus nuttallii - Sego lily. Coulee bottoms and lower slopes. Uncommon in North Dakota where it is found in the extreme western part. More common in Montana.

Fritillaria atropurpurea - Leopard lily. Grassy slopes to forested areas.

Penstemon flavescens
Open or wooded often rocky slopes in the mountains. Found in Ravelli County, Montana and Idaho County, Idaho.

Tiarella trifoliata - False miterwort. Moist woods especially on streambanks. Found in northern Idaho and northwestern Montana often beneath Thuja plicata.

Trientalis latifolia - Starflower. Woods and prairies. Found in Idaho on the North Fork of the Clearwater and Lochsa-Selway Rivers.

IV. Shrubs and Trees

Celtis reticulata - Netleaf hackberry. Rocky canyon slopes, or valleys along streams. World record is on BLM land on the Snake River 30 miles north of Lewiston, Idaho.

Pinus ponderosa - Ponderosa pine. Dry areas at lower elevations. Uncommon in North Dakota where it is limited primarily to the badlands in Slope and McKenzie Counties. Common on suitable habitat elsewhere in the Region.

Rubus nivalis - Snow dewberry. Moist areas in the mountains usually beneath *Thuja plicata* or *Abies grandis*. Common on the North Fork of the Clearwater in Idaho.

Rubus pedatus - Strawberry leaf blackberry. Moist areas in open to dense woods. Probably restricted to the *Thuja*-*Tsuga* zone in the western part of the Region.

ENDANGERED PLANTS FOUND IN THE NORTHERN REGION

All plants listed as rare or uncommon are considered to be endangered because of their limited distribution. Some species are rare or uncommon only in some parts of the Region, and are considered as endangered only in those areas.

In addition, other plants are endangered because of man's impact on their specific habitat, overcollecting, or because of disease. The following plants fit into this category:

ENDANGERED PLANTS FOUND IN THE NORTHERN REGION

I. Forbs

Goodyera spp. - Rattlesnake plantain. Dry or moist, open to dense forests. May be endangered at least in eastern Washington due to overcollecting.

Habenaria orbiculata
Moist mossy forests usually in the *Tsuga-Thuja* zone. May be endangered by logging of climax stands.

Listera spp. - Twayblade. Usually moist shaded areas in the *Tsuga-Thuja* zone. May be endangered by logging of climax stands.

Pyrola spp. - Wintergreen. Moist to dry coniferous forests. Attractive ornamentals that may be endangered, at least in eastern Washington, due to overcollecting.

II. Shrubs and Trees

Chimaphila spp. - Prince's pine. Coniferous woods. All species are attractive ornamentals. May be endangered by overcollecting in eastern Washington.

Cornus canadensis - Bunchberry dogwood. Moist woods usually in the Pachistima myrsinites union. Attractive ornamental that may be endangered at least in eastern Washington due to overcollecting.

Juniperus scopulorum - Rocky Mountain juniper. Dry plains and lower mountains. The columnar phase of this species is limited in North Dakota and is possibly endangered due to strip coal mining.

Pinus albicaulis - Whitebark pine. A timberline tree. Possibly endangered where its range overlaps Pinus monticola due to blister rust.

INT Missoula FSL

4210 Range and Wildlife Habitat Program April 18, 1974

Re. Rare & Endangered Plant Species

Charles E. Harnish, Multiple Use Coordinator
Helena National Forest
Helena, Montana
Attn: H. Wayne Phillips, Forester

My much delayed reply to your letter of March 4 requesting comment on rare and endangered plants results from the efforts to marshal information developing into much more of an undertaking than had originally been envisioned.

In reviewing some of the references cited in your letter it becomes apparent that our "rare" plants do not fit the description used for animals (i.e. "endangered," "threatened", etc.) nor the definition given in the "Endangered Species Act of 1973" (P.L. 93-205, Sec. 3(4)). I do not believe we have a single species that would qualify under the "endangered species" definition given as "any species in danger of extinction throughout all or a significant portion of its range. . ." In practically all, if not all, cases we do not have enough occurrence or distribution information on any given species that would enable us to assess its status under such a definition.

Within the same references I encountered no definition for "rare" plant species. In my opinion there are two general categories of rare plants, (1) genuine rare species, and (2) peripheral rare species. The genuinely rare plant species has always comprised a small population. This population may be distributed as widely scattered small groups of few individuals (such as some of the rare orchid species) or the population may be locally abundant but restricted to just one or a few locations (such as *Kelseya* or local endemics). Both of these situations usually result from specialized habitat (unique combination of environmental elements) that of themselves are of rare occurrence. A second type of genuine rare plant species is one that has been reduced from a large to a small population usually through habitat modification or destruction to the point that the species is restricted to small, isolated, remnant enclaves within its former range. Extensive cultivation and urbanization over large areas give rise to this type of rare plant situation. (Sort of the reverse of the peripheral and outlier idea.) This category of rare plant appears to approach the "threatened" category used for wildlife by the U. S. Bureau of Sports Fisheries and

Wildlife in their "Red Book" (Resource Publ. 114, March 1973, p.5) except they state it in terms of extinction. From the way the term is used it appears as though they are only concerned with extinction as total extinction of a species and not with extinction from an area or remnant site. This latter idea is an important element of my general concept of rare plant status.

The second general category of rare plants relates to peripheral species; that is species that are near or outlying the limits of their natural range. These are plant species that have large populations in the central portions of their range where their occurrences may be considered common. However, at or near their botanical limits they behave or appear as rare plants. These populations are particularly important to the genetic diversity of the species which from an evolutionary stand point, often contains the pre-adaptations to environmental change. This category of rare plant approaches the "peripheral" category used for wildlife in the "Red Book" (Resource Publ. 114, March 1973, p. 272) but without the stipulation of being threatened with extinction within the United States. (As stewards of the National Forests it appears to me that we should be concerned about "rare species" long before they get to the "threatened with extinction" stage.)

With these definitions in mind the SCS Environmental Memorandum MT-2, June 28, 1972 was reviewed and my comments on the rare plants listed are enclosed (see attachment). The comments offered were made with the additional consideration that for a plant to be rare in a given area, i.e. Montana or the Helena National Forest area, it must first be established to be present within that area. To reason otherwise would invite the inclusion of all the flora extraterritorial to the given area as rare plants. Plants listed as rare in adjacent areas should not be labeled as rare plants for the given area just because they occur in an adjacent area. There should be some additional basis for including "suspected" rare plants (such as the nature of the total distribution pattern or presents of suitable habitats, etc.). And even then they should be labeled as "suspected" or "expected" plants rather than rare plants per se.

As nearly as I am able to determine the "Rare Plant Species" listed (with 2 exceptions) on p. 2-4 of the MT-2 memo were taken verbatum from a more extensive list assembled in 1971 by John P. Inman, L. Hendzel, and Jack E. Schmautz, for the Northern Region (R-1, USFS). In the original version the locations of rare occurrence within the Region were given and these were edited out of the "Montana Rare Plants" list. What criteria, then, was used (if any) for including species on the Montana rare plants listing remains a mystery. It appears that all plants mentioned for Montana or of general distribution and some, but not all, of those listed for northern Idaho were included. Hence, the list includes many plant species that have no basis as yet for being considered as rare plants in Montana.

With regard to addition to this list of rare, unfortunately I am not familiar enough with the flora of the Helena N. F. area to be of much specific help. Certainly such a unique plant as Kelseya uniflora warrants your attention and consideration. Also any species that are local endemics (such as Kelseya) should be accorded rare plant status. In this same class Phlox albomarginata is a candidate species. Characteristically a low plant of rocky places at high elevations, it was collected on the east face of Mt. Helena in 1891.

I am not aware of any research being conducted to identify or enumerate plant species as "rare" and/or "endangered." Any species that is specific to a habitat that is endangered is of necessity itself endangered. For this reason rare species are most likely to be the endangered species. While I am unable to direct you to a ready source of information on rare plants, I have several suggestions for developing a preliminary list of candidate species for the Helena National Forest area. (1) A survey and careful perusal of the floras that include your geographic area could establish a comprehensive list of candidate species. In this case I'm thinking primarily of Booth and Wright's Flora of Montana (1950, 1966) used in conjunction with Hitchcock's (et al. 1955-1969) Vascular Plants of the Pacific Northwest. (2) Another idea, not as comprehensive but less work would involve utilizing Pfister's habitat type data for the Helena N. F. All species that did not occur in a minimum of at least 5 stands were excluded from the ADP input data and analysis. By comparing output listings against field data cards a first approximation of candidate species could be obtained. Note that this approach would ignore all species that do not occur in forest vegetation. Pfister, Arno, and Kovalchik could advise much better than I on the feasibility and practicality of this approach. But a tremendous amount of floristic data is contained therein, and the like of this information is not matched elsewhere for forest vegetation, not even in the herbaria of our state universities. (3) A third approach could involve a floristic survey of potential or suspected "rare plant habitats." From a preliminary listing of species on these sites a list of the suspected rare plant species could be developed. (See BK's comments on Montana Rare Plants list attached in this regard.)

It is my considered opinion that the most effective and pragmatically successful approach to the rare plant problem in multiple use planning and its application in the field lies not so much in the construction of rare plant species lists but rather in the description and recognition of "rare plant habitats." This approach would not automatically guarantee covering all rare plant species but it would certainly cover a majority of them. In general rare plant habitats would be easier for field personnel to recognize than rare plants. And they could be recognized year 'round and not just limited to the flowering period. The mere fact that district and field people are aware of the possible presence of "rare plant habitats" would be an important step toward the goal of incorporating this type of thing into multiple-use planning.

So far as I am aware the identification and listing of rare plant habitats has not been done either. However, I believe this would be easier to do than to construct a meaningful and comprehensive lists of rare plant species for the Helena N. F.

In general terms "rare plant habitats" may be characterized as areas (usually limited in size) that poses a combination of environmental elements that make them unique or unusual in terms of the general or typical vegetation. Be alert to sites with special moisture or substrate characters. Unusual combinations or extremes in such environmental elements as moisture, shading, substrate, wind exposure, elevation, and topography or land form provide useful clues to these kind of habitats. A cursory consideration of some of these environmental elements suggests the partial and incomplete listing given below of the potential rare plant habitat sites that might be expected in your area. Also mentioned are a few of the rare plants that could be associated with such sites in your area. I want to emphasize the fragmentary and incomplete nature of the material presented below. Undoubtedly you will find many situations not suggested here.

POTENTIAL RARE PLANT HABITATS FOR THE HELENA N. F. AREA

A. MOISTURE: sites where moisture is the key or extreme factor.

1. Aquatic habitats (open still or slow moving water) Marshes, Ponds, etc.

2. Bog habitats (closed wet depressions, treeless, graminoides predominant). Ring bog or lake margin bogs, Quaking bogs, Sphagrum bogs (site for Drosera rotundifolia and D. angelica plus other semi-aquatic species, potential for rare sedges and other Cyperaceae).

3. Wet meadows (perennially wet saturated ground, treeless). Alkalie wet meadows (lower elevation, site for Hierochloa oderata. Subalpine and alpine wet meadows, site for Hierochloa species and scarce to rare high elevation shrubs.

4. Hot springs and thermal pools. A very specific and restricted habitat for certain species of plants that are widely disjunct or otherwise rare.

B. SUBSTRATE: sites where the type of bedrock has an overriding influence on vegetation and species present.

SCS RARE PLANT SPECIES LISTING FOR

MONTANA[1/]

Peter F. Stickney, APE
FSL Missoula, Montana

April 5, 1974

Comments on the rareness of the following species are made with primary reference to the geographic area encompassed by the Helena National Forest and secondarily with reference to the flora of Montana.

I. Ferns, Mosses, and Fungi:

1. Adiantum pedatum:

   Not known to be present in the Helena N. F. area; most probably restricted to the most mesic western redcedar and/or western hemlock forest types in extreme western and northwestern Montana. Outside (eastward) of this general area it may be considered peripherally scarce and *if* ever found in the Helena N. F. area it should be accorded the protection for a rare plant.

2. Asplenium trichomanes:

   Known from Montana only from Glacier National Park; probability of being present in the Helena N. F. area unknown but suspected to be low. Worthy of protection if found in this area.

3. Botrychium:

   Hitchcock et al. (1969) states of the grape ferns, "They are now so rare, that they should be left strictly alone by all fortunate enough to discover them." The occurrence of grape ferns in the Helena N. F. area is unknown but it is possible that some of the 6 species reported as occurring in Montana may be present in the Helena N. F. area. Their habitats are isolated, widely scattered, and locally restricted and if found should be protected.

[1/] Environmental Memorandum MT-2 date June 28, 1972. Issued by the State Conservationist SCS, Montana.

II. Grasses and Grasslike Plants

4. Hierochloa odorata:

Probably present in the Helena N. F. area. In 1960 Jack E. Schmautz collected it along old highway 10N in a wet meadow 4 miles southeast of Townsend; also collected in 1914 from Mullegan Ranger Station on the old Jefferson N. F. Not enough information available to accurately assess the rareness of this grass. At this point it certainly appears that it is uncommon and possibly scarce.

5. Leersia oryzoides:

Not reported for Montana by Hitchcock et al. (1969). Jack Schmautz collected it in for western Montana on banks of a hot spring at Lolo Hot Springs in 1966. This collection may constitute the first record for state. Its presence on the Helena N. F. is unknown but it probably does not occur.

6. Both species of Scirpus are reported for Montana, but neither from the Helena N. F. area of Montana. Both species inhabit and are apparently restricted to boreal (cold) wet sites, such as sphagnum bogs, etc. As aquaties their distribution can be expected locally restricted, highly isolated and widely scattered. If found in Helena N. F. area should be treated as other rare peripheral species.

7. Scolochloa festucacea:

This aquatic grass of lakes, streams, and standing water is reported by Hitchcock et al. (1969) for Montana from FLATHEAD CO. In as much as it is an introduced (alien) plant, I am puzzled by its inclusion on rare plants list of presumably rare native and endemic plants. (The list could be considerably broadened by including introduced plants that are barely making it--unsuccessful weeds so to speak.)

8. Trisetum orthochaetum:

A super rare species that in all probability now extinct. Known only from the "type locality", boggy meadows at Lolo Hot Springs, where collected by Agnes Chase in 1908 and, to the best of my knowledge, not since recollected. The commercial development of the hot springs has reduced the "boggy meadow" to a parking lot and buildings.

III. Forbs

9. Allium bisceptrum:

Apparently not a member of the Montana flora. Closest known station is a disjunct in the Selway River of Idaho which is a northern outlier for the species which generally occurs in the mountain ranges of the Great Basin in Nevada and southern Idaho.

10. Aster subspicatus:

Hitchcock et al. (1955) notes this species as rarely in Montana; however, he also notes that it is highly variable and also similar to Aster foliaceus which in itself is highly variable. The possibility of intergradation between these two variable species makes specific determination difficult for the expert muchless the man in the field. Pragmatically, this and the fact that if the problem existed it most likely occurs in the Beaverhead and Gallatin N. F. areas, I would not be concerned about this species in the Helena N. F. area.

11. Boykenia major var. intermedia:

The variety "intermedia" is described by Hitchcock et al. (1961) as occurring on the "Olympic Peninsula south to Tillamook Co., Oregon" wholely west of the Cascade Range. The variety "major" is infrequent but not scarce throughout the western portion of western Montana. In view of this distribution it is highly unlikely that the variety "intermedia" occurs in the Helena N. F. area.

12. Calochortus elegans var. selwayensis:

In Montana this species (including the variety) is not known to occur east of the Bitterroot Valley or north of the general axis of the Clark Fork River from Missoula to Pend Oreille Lake. Within this circumscribed area for Montana its occurrence in openings and open woods within the forest zone is frequent (occassionally common but certainly not rare). It is highly unlikely that this species or its variety are present in the Helena N. F. area.

13. Calypso bulbosa:

Certainly not rare in western Montana on northerly, moist wooded sites where its occurrence is infrequent to occasionally very locally common. Next to Goodyera possibly one of our most frequently encountered orchids. Probably the greatest potential hazard posed to this species in clearcutting forest sites to which it appears to be specifically restricted.

14. Collomia heterophylla:

An annual plant characteristically occurring west of the Cascade summit. A disjunct in the Lochsa River area of northern Idaho represent the closest known approach to Montana. No collections known for Montana. It is highly improbably that this plant will be found in the Helena N. F. area.

15. Corallorhiza:

There are five species of Corallorhiza recorded for Montana and potentially all five species could occur in the Helena N. F. area. You should be particularly alert for C. wisteriana and C. trifida which, in my experience, appear to be the rarest of this group. All our species are mycotrophic (parasitic on fungi, mycorhiza; erroneously termed saprophytes) and as such require successionally well developed to mature forest stands as habitat. Characteristically they occur as a few scattered individuals. Very rarely, however, they may occur in large numbers in densely packed clumps. I believe that the Corallorhiza are an example of a plant that is dependent on mature forest stands for survival. These species are never associated with early forest succession so that clearcutting and other forms of overstory removal destroy the habitat of these plants.

16. Cypripedium:

Of the 4 species of this orchid genus recorded for Montana the occurrence of 3 of them are reported by Hitchcock et al. (1969) as very rare for the Pacific Northwest. Records available to me in Missoula indicate that for Montana we have the following minimal distribution:

Species	No. of Counties of Record/Comment
C. calceolus	3, rare, identical to C. montanus except for yellow slipper (lip)
C. fasciculatum	1 (Lake Co.), very rare
C. montanum	7 (incl. Lewis & Clark Co.), most frequently encountered species, scarce to uncommon (very locally common) but not rare, white slipper (lip).
C. passerinum	2 (incl. Lewis & Clark Co.), very rare.

The habitat of two of these species (C. fasciculatum and C. montanum) may be characterized as open forest on somewhat dry or warm upland slopes. The other two (C. calceolus and C. passerinum) appear to be specific to bogs or moist springy sites in mossy woods. Because of their apparent rareness all species of this genus should receive all the protection we as a land managing agency can provide.

17. Dodecatheon dentatum:

A species of the east slope of the Cascade Range occupying moist (wet) shade sites. Outlier locations in Clearwater Co. and three other sites in northern Idaho constitute the closest approach known to Montana. So far as can be determined no record for Montana and, therefore, not a part of Montana's flora.

18. Fritillaria atropurpurea:

This species is widely distributed throughout Montana. Its greatest concentration appear to be in open forests stands in the Little Belt Mountains where B. L. Kovalchik reports it to be frequent to occasionally locally common. Kovalchik states that it is "very common if you look for it in Helena" (N.F.). I have never encountered populations such as BLK describes, but for western Montana I would rate it as a scarce to infrequent plant. In any event I would not consider it to be a rare species.

19. Ivesia tweedyi:

At present this species according to Hitchcock et al. (1961) is known only from east side of Cascade Mountains (where often on serpentine soil) with a disjuncted outlier occurring in northern Idaho in the Coeur d'Alene Mountains. It is unreported for Montana and unlikely to occur in the Helena N. F. area.

20. Lathyrus bijugatus:

Hitchcock et al. (1961) limit this species to extreme eastern Washington and adjacent Idaho. Booth and Wright (1966) show it occurring in Flathead County; however, Hitchcock questions the validity of its occurrence in Montana. Another species that is unlikely to occur in the Helena N. F. area.

21. Lilium philadelphicum:

A widely distributed species ranging from the eastern edge of the Rocky Mountains eastward to the Atlantic states. A species whose occurrence is apparently never common in Montana with a population that is widely scattered and relatively isolated

presumably due to the presence of suitable habitat. Reported to occur in alkalie meadows, aspen groves, spruce and moist Douglas-fir forest stands. It has been found on the Lewis and Clark N. F. and is to be expected in the Helena N. F. area where its occurrence will probably be scarce to rare.

22. Sanicula marilandica:

Another widely distributed species, Northern Rocky Mountains eastward to the Atlantic states where probably more common. In Montana it appears to be restricted in habitat to moist low ground at moist woods at lower elevations. Probably more correctly classified as a scarce to infrequent plant rather than rare. To be expected in Helena N. F. area in appropriate habitats.

23. Tofieldia glutinosa var. absona:

In the Pacific Northwest Hitchcock et al. (1969) indicates that T. glutinosa is composited of 3 well defined geographic races. Of these the var. absona is known only from near Priest Lake in northern Idaho. It is unlikely that this variety occurs in Montana.

24. Veratrum californicum var. caudatum:

With the exception of one location cited for Idaho Co., Idaho (Hitchcock et al., 1969) the var. caudatum appears to be geographically restricted to the area west of the Cascade Mountains. It appears improbable that this variety occurs in the Helena N. F. area or in Montana. The typical variety of this species, V. californicum var. californicum, is common in west central and southern Idaho. Farther south and east it is the only species reported for Nevada, Utah, and Wyoming. With one apparent exception the typical variety also appears to be absent from Montana. Hitchcock et al. (1969) reports this variety for Montana on the basis of an 1896 collection taken from the Bridger Mts. north of Bozeman. However, none of Pfister's habitat-type field crews working Beaverhead, Gallatin, or Custer N. F. areas found or saw any evidence of this species (only V. viride observed). Possibly the northern limit of typical var. californicum lies somewhere in the Yellowstone National Park area. It would appear then, that there is a remote possibility that the typical variety may occur in the Helena N. F. area (if so then most probably in the southern end of the Big Belt Mts. where it would be considered a peripherally rare species).

25. Veronica wormskjoldii:

A wide ranging plant of alpine and boreal habitats in North America. In Montana it has been collected from at least 10 alpine mountain ranges and from 12 counties (including Lewis and Clark Co.) in the western one-third of the state. K. H. Lackschewitz of the Univ. of Montana Botany Department states (pers. comm., 1973) that it is not rare in Montana and suggests that ultimately it will probably be found to occur on all the mountain ranges in the states with alpine vegetation.

26. Ribes howellii:

This species of wild current occurries in the Cascade Mountains with a disjuncted outlier reported (Hitchcock et al. 196) for northern Idaho in the Selkirk Range just east of Priest Lake. Its occurrence in the Helena N. F. area is improbable.

27. Vaccinium oxycoccus:

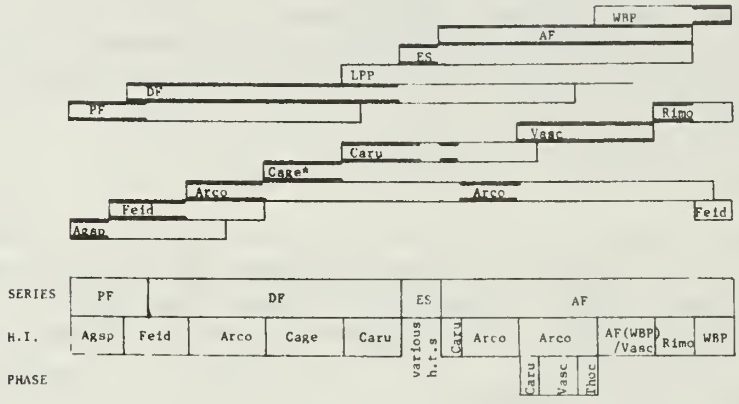
Not known to occur in Montana. Reported for northern Idaho and adjacent Washington (E. F. Layser, pers. comm., 1972). If this species is present in Montana it will most probably be found in sphagnum bogs in Lincoln or Flathead Counties. Its prescence in the Helena N. F. area is improbable.

28. Viburnum edule:

A widely distributed shrub of the boreal zone in North America. In the mountainous western third of Montana it is widely scattered and locally isolated to cool, moist, valley bottom forests. It has been collected or recorded from 5 counties (3 northwestern and 2 south central Montana) where reported to be of rare or scarce occurrence. Possibly present in the Helena N. F. area in suitable habitats. (A species of interest and record if found.)

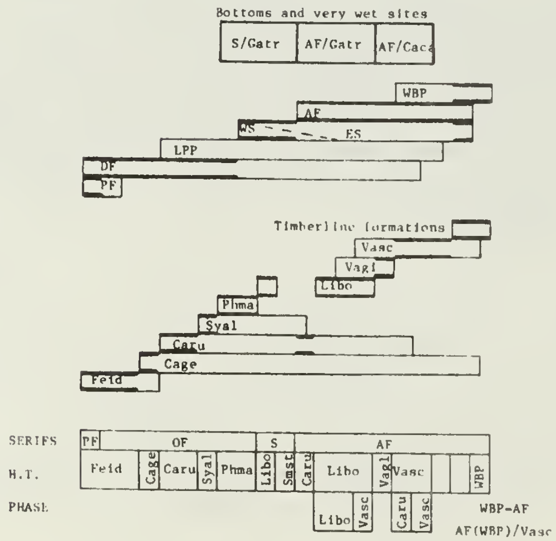
D. DISTRIBUTION OF HABITAT TYPES IN THE DILLON-LIMA VICINITY AND MADISON TO BEARTOOTH RANGES

FIGURE 8. GENERALIZED DISTRIBUTION OF HABITAT TYPES IN THE DILLON-LIMA VICINITY



* the upper limits of Cage are not well defined.

FIGURE 11. GENERALIZED DISTRIBUTION OF HABITAT TYPES IN THE MADISON-TO-BEARTOOTH RANGES



(Reproduced from Pfister et al. (1974)

LITERATURE CITED

Anderson, Norman L. 1973. The vegetation of rangeland sites associated with some grasshopper studies in Montana. Mont. Agr. Exp. Sta. Bull. 668. 47 pp.

Anonymous. 1972. Electrical world. 178:9.

Arner, Dale H. 1951. Experimental plantings on power line right-of ways and woodland roads. Trans. N. Amer. Wild. Conf. 16:331-38.

Arner, Dale H. 1966. Utility line right-of-way management. Trans. N. Amer. Wild. Conf. 31:259-269.

Arnold, Joseph F. 1955. Plant life form classification and its use in evaluating range conditions and trend. J. Range Man. 8:176-181.

Audus, L.J. 1960. Magnetotropism: A new plant growth response. Nature 185(4707):132-34.

Bamberg, S.A., and J. Major. 1968. Ecology of the vegetation and soils associated with calcareous parent materials in three alpine regions of Montana. Ecol. Mong. 38:127-67.

Bayless, Stephen R. 1969. Winter food habits, range use, and home range of antelope in Montana. Jour. Wild. Man. 33(3):538-551.

Barnothy, Madeleine F. 1969. Biological effects of magnetic fields. Vol. 2. New York and London: Plenum Press.

Beardsley, Wendell G., and J. Alan Wagar. 1971. Vegetation management on a forested recreation site. J. For. 69:728-31.

Bell, K.L. and L.C. Bliss. 1973. Alpine disturbance studies: Olympic National Park, U.S.A. Biol. Conserv. 5:25-32.

Blaisdell, James P., and Joseph F. Pechanec. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. Ecology 30(3):298-305.

Bogle. 1973. Microfische bibliography of the effects of air pollution on plants. E.P.A., Corvallis, Oregon.

Booth, W.E. 1947. The effects of grass competition on growth and reproduction of sagebrush. Proc. Mont. Acad. Sci. 7:23-24.

Bormann, F.H., G.E. Likens, D.W. Fisher, and R.S. Pierce. 1968. Nutrient loss accelerated by clearcutting of a forest ecosystem. Science 159:882-884.

Branson, Farrel A. 1956a. Responses of fertile and sterile ecotypes of _Stipa comata_ to simulated grazing treatments. Proc. Mont. Acad. Sci. 16:17-19.

Branson, Farrel A. 1956b. Quantitative effects of clipping treatments on five range grasses. J. Range Man. 9:86-88.

Branson, Farrel A. 1955. Relationships of grass morphology to grazing resistance. Proc. Mont. Acad. Sci. 15:41-43.

Branson, Farrel A. 1953. Two new factors affecting resistance of grasses to grazing. J. Range Man. 6:165-71.

Bramble, W.C. and W.R. Byrnes. 1972. A long-term ecological study of game food and cover on a sprayed utility right-of-way. Lafayette; Purdue University, Agricultural Exp. Sta. Res. Bull. 885:20 pp.

Bramble, W.C. and W.R. Byrnes. 1967. Ecological aspects of brush control - a long term study on a utility right-of-way. Lafayette: Purdue University, Agricultural Exp. Sta. Res. Bull. 835:12 pp.

Britton, Michael P. 1955. An ecological study of a relict of grassland and an adjacent grazed pasture in the Beaverhead Valley, Montana. Unpublished Master's thesis. Montana State College, Bozeman.

Brown, Ray W. 1971. Distribution of plant communities in southeastern Montana badlands. The Amer. Midl. Nat. 85(2):458-477.

Buchanan, Bruce Albert. 1972. Ecological effects of weather modification, Bridger Range area Montana: Relationships of soil, vegetation and microclimate. Unpublished thesis. Montana State University, Bozeman.

Choate, Charlu M., and James R. Habeck. 1967. Alpine plant communities at Logan Pass, Glacier National Park. Proc. Mont. Acad. Sci. 27:36-54.

Cieslinski, Thomas J., and J. Alan Wagar. 1970. Predicting the durability of forest recreation sites in northern Utah - preliminary results. U.S.D.A. For. Ser. Res. Note Int-117. 7 pp.

Cook, C. Wayne. 1971. Effects of season and intensity of use on desert vegetation. Utah Agr. Exp. Sta. Bull. 344.

Costello, David F. 1944. Natural revegetation of abandoned plowed land in the mixed prairie association of northeastern Colorado. Ecology 25:312-26.

Cottam, G. and R.P. McIntosh. 1966. (Reply to Daubenmire 1966). Science 152:546-7.

Cotter, James F. 1963. Causation and plant succession in disturbed areas of southwestern Montana. Unpublished Master's thesis. Montana State University, Bozeman.

Countryman, Clive M., and Donald R. Cornelia. 1957. Some effects of fire on a perennial range type. J. Range Man. 10:39-41.

Dale, D.R. 1973. Effects of trail use under forests in the Madison Range, Montana. Unpublished thesis. Montana State University, Bozeman.

Dale, D., and T. Weaver. 1974. Effects of horse, motorcycle and hiker trampling in native vegetation. Proc. Mont. Acad. Sci. 34:47.

Darley, E.F. 1970. Effects of dusts on vegetation. Nat. Air. Pollut. Cont. Assoc. AP-70:13.

Darley, E.F. 1967. Role of particle size in studies on effects of dust on vegetation. J. Air. Poll. Contr. Assoc. 17(9):579.

Darley, E.F., and J.T. Middleton. 1966. Problems of air pollution in plant pathology. Ann. Rev. Phytopathol. 4:103-108.

Daubenmire, R. 1973. A comparison of approaches to the mapping of forest land for intensive management. Forestry Chron. 48(2):87-91.

Daubenmire, R. 1970. Steppe vegetation of Washington. Wash. Agr. Exp. Sta. Tech. Bull. No. 62. 131 pp.

Daubenmire, R. 1969. Structure and ecology of coniferous forests of the northern Rocky Mountains. In: Coniferous forests of the northern Rocky Mountains. (Symposium, Univ. Montana, Missoula):25-41.

Daubenmire, R. 1966. Vegetation: Identification of typal communities. Science 151:291-8.

Daubenmire, R. 1940. Plant succession due to overgrazing in the Agropyron bunchgrass prairie of southeastern Washington. Ecology 21(1):55-64.

Daubenmire, R. and Jean B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Wash. Agr. Exp. Sta. Tech. Bull. No. 60. 104 pp.

Davis, Carl. 1975. A guide for determining potential herbage productivity of central Montana range areas and potential range areas. Mimeo, Gallatin National Forest. Supplemented May 9, 1975. 54 pp.

Deitschman, Glenn H. 1973. Mapping of habitat types throughout a national forest. U.S.D.A. Forest Service Tech. Report INT-11. 15 pp.

Dohrenwend, Robert E. 1973. Environmental management during power transmission line construction: operational considerations. In: Power lines and the environment, Robert Goodland (Ed.) Millbrook, N.Y. The Cary Arboretum of the New York Bot. Gardens, p. 58-76.

Driscoll, Richard S. 1957. Effects of intensity and date of herbage removal on herbage production of elk sedge. J. Range Man. 10:212.

DuMond, David M. 1973. A guide for the selection of rare, unique and endangered plants. Castanea 38(4):387-395.

Egler, Frank E. 1974. Commentary - instant ecology in academia. Ecology 55:691-92.

Egler, Frank E. 1973. (Newly published book on right-of-way management.)

Egler, Frank E. 1958. Science, industry, and the abuse of rights-of-way. Science 127:573-580.

Egler, Frank E. 1957. Rights-of-way and wildlife habitat; a progress report. Trans. N. Amer. Wildl. Conf. 22:133-44.

Egler, Frank E. 1953a. Our disregarded rights-of-way -- ten million unused wildlife acres. Trans. N. Amer. Wildl. Conf. 18:147-158.

Egler, Frank E. 1953b. Vegetation management for rights-of-way and roadsides. Ann. Report. Smithsonian Institution (1953):299-322.

Ellison, Lincoln. 1960. Influence of grazing on plant succession of rangelands. Bot. Rev. 26(1):1-76.

Ellison, Lincoln. 1949. The ecological basis for judging condition and trend on mountain range land. J. For. 47:786-95.

Energy Planning Division, Montana State Department of Natural Resources and Conservation. 1974. Draft environmental impact statement on Colstrip electric generating units 3 and 4, 500 kilovolt transmission lines and associated facilities: Vol. 4, Transmission Lines. Helena, Montana. 437 pp.

Fern, W.J., and R. I. Brabets. 1974. Field investigation of ozone adjacent to high voltage transmission lines. IEEE Transaction Paper. T74 0 57-6.

Foote, G.G. 1965. Phytosociology of the bottomland hardwood forests in western Montana. Unpublished thesis. University of Montana, Missoula.

Frydman, M., A. Levy, and S.E. Miller. 1972. Oxidant measurements in the vicinity of energized 765 kV lines. IEEE Transaction Paper. T72 551-0.

Gardner, W.R., R.F. Harris, and C.B. Tanner. (No date). Response of plants and soil microorganisms to extremely low frequency electric fields. Unpublished report conducted by Dept. of Soil Science, U. of Wisconsin for Office of Naval Research, Contract No. N00014-67-A-0128-0020. 84 pp.

Garrison, G.A. 1953. Effects of clipping on some range shrubs. J. Range Man. 6:309-317.

Goodland, Robert. 1973. Ecological perspectives of power lines. In: Power Lines and the Environment. Robert Goodland, Ed. Millbrook, N.Y. The Cary Arboretum of the N.Y. Botanical Gardens. pp. 1-35.

Griggs, Robert F. 1938. Timberlines in the northern Rocky Mountains. Ecology 19(4):548-64.

Gysel, Leslie W. 1962. Vegetation and animal use of a power line right-of-way in southern Michigan. Michigan Quarterly Bulletin 44(4):697-713.

Habeck, J.R., and T.W. Weaver. 1969. A chemo-systematic analysis of some hybrid spruce (Picea) populations in Montana. Can. J. Bot. 47:1565-70.

Heady, Harold F. 1950. Studies on bluebunch wheatgrass in Montana and height-weight relationships of certain range grasses. Ecol. Monog. 20(1):56-81.

Hindawi, Ibrahim Joseph. 1970. Air pollution damage to vegetation. Raleigh, North Carolina: U.S. Dept. of H.E.W., Public Health Service, National Air Pollution Control Administration. 44 pp.

Jameson, Donald A. 1963. Responses of individual plants to harvesting. Bot. Rev. 29(4):532-94.

Jameson, Donald A. 1952. The chemical composition and utilization of greasewood and other browse species as related to some aspects of cattle nutrition and winter ranges in southeastern Montana. Unpublished thesis. Montana State College, Bozeman.

Jameson, Donald A., and D.L. Huss. 1959. The effect of clipping leaves and stems on number of tillers, herbage weights, root weights, and food reserves of little bluestem. J. Range Man. 12:122-26.

Johnson, James Russell. 1966. The effects of some environmental influences on big sagebrush, Artemisia tridentata, Nutt., reinvasion. Unpublished thesis. Montana State University, Bozeman.

Jorgensen, Henry Edward. 1970. Ecological aspects of the life history of Agropyron smithii Rydb. in central Montana with related effects on selective herbicide treatment of rangeland. Unpublished Master's thesis. Montana State University, Bozeman.

Kitchings, J.T., H.H. Shugart, and J.D. Story. 1974. Environmental impacts associated with electric transmission lines. Oak Ridge, Tenn.: Oak Ridge National Laboratory. ORNL-TM-4498. 100 pp.

Knowlton, Frederick F. 1960. Food habits, movements and populations of moose in the Gravelly Mountains, Montana. J. Wild. Man. 24(2):162-170.

LaPage, Wilbur F. 1967. Some observations on campground trampling and ground cover response. U.S.D.A. Forest Service Res. Paper. NE-68. 11 pp.

LeBarron, Russell K., and George M. Jemison. 1953. Ecology and silviculture of the Engelmann spruce-alpine fir type. J. For. 51:349-55.

Liddle, M.J. 1975. A selective review of the ecological effects of human trampling of natural ecosystems. Biol. Conserv. 7:17-36.

Likens, Gene E. 1969. Nitrification: importance to nutrient losses from a cutover forested ecosystem. Science 163:1205-6.

Lynch, D.L. 1955. Ecology of the aspen groveland in Glacier County, Montana. Ecol. Monog. 25:321-44.

Marha, Karel, Jan Musil, and Hana Tuha. 1971. Electromagnetic fields and the life environment. English translation. San Francisco: San Francisco Press, Inc.

Marks, P.L., and F.H. Bormann. 1972. Revegetation following forest cutting: mechanisms for return to steady-state nutrient cycling. Science 176:914-5.

Martin, Peter Raymond. 1973. Ecology of skunkbush sumac (Rhus trilobata Nutt.) in Montana with special reference to use by mule deer. Unpublished Master's thesis. Montana State University, Bozeman.

McKell, Cyrus M. 1975. Shrubs -- a neglected resource of arid lands. Science 187:803-9.

Medin, Dean E. and Robert B. Ferguson. 1972. Shrub establishment on game ranges in the northwestern United States. In: Wildland shrub -- their biology and utilization. U.S.D.A. Forest Ser. Gen. Tech. Pap. INT-1.

Megahan, W.F., and W.J. Kidd. 1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. J. For. 70:136-141.

Miller, P. Robert, John R. Parmeter, Jr., O.C. Taylor, and E.A. Cardiff. 1963. Ozone injury to the foliage of Pinus ponderosa. Phytopathol. 53:1072-76.

Miller, P. Robert, John R. Parmeter, Jr., Brigitta H. Flick, and C.W. Martinez. 1969. Ozone damage dosage response of ponderosa pine seedlings. J. Air Poll. Cont. Assoc. 19(6): 435-438.

Moir, William H. 1969. The lodgepole pine zone in Colorado. Amer. Midl. Nat. 81(1):87-98.

Monroe, Robert E. 1949. The response of western and bluebunch wheatgrass seedlings to clipping and pulling. Unpublished Master's thesis. Montana State College, Bozeman.

Montana Agricultural Experiment Station. 1973. Vegetation rangeland types in Montana. Bull. 671. 15 pp.

Morris, M.S. 1946. An ecological basis for the classification of Montana grasslands. Proc. Mont. Acad. Sci. 6:41-44.

Morris, M.S., J.E. Schmautz and P.F. Stickney. 1962. Winter field key to the native shrubs of Montana. U.S.D.A. Forest Service Int. Range and Exp. Sta. Bull. No. 23. 70 pp.

Morris, H.E., W.E. Booth, G.F. Payne and R.E. Stitt. 1950. Important grasses on Montana ranges. Mont. Agr. Exp. Sta. Bull. 470. 51 pp.

Mueggler, W.F. 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. Jour. Range Man. 25(2):88-92.

Mueggler, W.F. 1972a. Plant development and yield on mountain grasslands in southwestern Montana. U.S.D.A. For. Ser. Res. Pap. INT-124. 20 pp.

Mueggler, W.F. 1970. Influence of competition on the response of Idaho fescue to clipping. U.S.D.A. For. Ser. Res. Pap. INT-73. 10 pp.

Mueggler, W.F. 1967. Response of mountain grassland vegetation to clipping in southwestern Montana. Ecology 48(6):942-49.

Mueggler, W.F., and W.P. Handl. 1974. Mountain grassland and shrubland habitat types of western Montana. Interim report. U.S.D.A. Forest Service. 89 pp.

Mueggler, W.F., and C.A. Harris. 1969. Some vegetation and soils characteristics of mountain grasslands in central Idaho. Ecology 50(4):671-78.

Murr, L.E. 1966. Physiological stimulation of plants using delayed and regulated electric field environments. Int. J. Biometeor. 10(2):147-153.

Murr, L.E. 1965a. Biophysics of plant growth in an electrostatic field. Nature 206(4983):467-470.

Murr, L.E. 1965b. Plant growth response following exposure to a short duration electrostatic field. Penn. Acad. of Sci. 38:44-46.

Murr, L.E. 1964. Mechanism of plant-cell damage in an electrostatic field. Nature 201(4926):1305-6.

Murray, Earl P. 1974. Species composition of a near-pristine grassland community. Proc. Mont. Acad. Sci. 34:1-4.

Mussehl, Thomas W. 1960. Blue grouse production, movements and populations in the Bridger Mountains, Montana. J. Wild. Man. 24(1):60-68.

National Academy of Science. 1968. Subcommittee on weeds. Washington, D.C. Publication No. 1597.

Nelson, E.W. 1936. Some phases of the land use problem in Montana. The Forestry Kaimin, (1936):14-23.

Niering, W.A. 1958. Principles of sound right-of-way vegetation management. Econ. Bot. 12:140-44.

Patten, D.T. 1969. Succession from sagebrush to mixed conifer forest in the northern Rocky Mountains. Amer. Midl. Nat. 82(1):229-240.

Patten, D.T. 1968. Dynamics of the shrub continuum along the Gallatin River in Yellowstone Natn'l Park. Ecology 49(6):1107-1112.

Patten, D.T. 1963. Vegetational pattern in relation to environments in the Madison Range, Montana. Ecol. Monog. 33(4):375-406.

Payne, Gene F. (No date) The effect of 2,4-D on sagebrush and associated vegetation on the Beaverhead National Forest, Montana. Final report, administrative study: U.S. Forest Service and Mont. Agr. Exp. Sta.

Payne, Gene F. 1974. Cover-weight relationships. J. Range Man. 27(5):403-404.

Payne, Gene F. 1973. Vegetative range land types in Montana. Mont. Agric. Exp. Sta. Bull. No. 671. 15 pp.

Peck, Stanley Vernon. 1972. The ecology of the Rocky Mountain goat in the Spanish Peaks area of southwestern Montana. Unpublished thesis. Montana State University, Bozeman.

Pengelly, W.L. 1972. Clearcutting: detrimental aspects for wildlife resources. J. Soil Water Conserv. 27:255-8.

Pengelly, W.L. 1962. Timberlands and deer in the northern Rockies. J. of For. 61(3):734-40.

Peterson, Roald A. 1962. Factors affecting resistance to heavy grazing in needle-and-thread grass. J. Range Man. 15(4):183-9.

Pfister, Robert D., Bernard L. Kovalchik, Stephen F. Arno, and Richard C. Presby. 1974. Forest habitat types of Montana. U.S.D.A. Forest Service, Intermountain Forest and Range Exp. Station, Northern Region. Missoula, Montana. 213 pp.

Pfister, R.D., J. Schmautz, and C. Brown. 1971. Management implications by habitat type. U.S.D.A. For. Serv. Region 1, Missoula, Montana (presented at H.T. training session at Coeur d'Alene, Idaho) 30 pp.

Pond, Floyd W. 1960. Vigor of Idaho fescue in relation to different grazing intensities. J. Range Man. 13:28-30.

Pound, E. and Egler, F.E. 1953. Brush control in southeastern New York: Fifteen years of stable tree-less communities. Ecology 34:63-73.

Pressman, A.S. 1970. Electromagnetic fields and life. New York and London: Plenum Press.

Reed, R.M. 1971. Aspen forests of the Wind River Mountains, Wyoming. Amer. Midl. Nat. 86(2):327-343.

Reitz, Louis P., and H.E. Morris. 1939. Important grasses and other common plants on Montana ranges. Mont. St. Coll. Agr. Exp. Sta. Bull. No. 375.

Resler, Rexford A. 1972. Clearcutting: beneficial aspects for wildlife resources. J. Soil and Water Conserv. 27:250-4.

Rich, Saul. 1964. Ozone damage to plants. Ann. Rev. Phytopathol. 2:253-66.

Richards, N.A. 1973. Old field vegetation as an inhibitor of tree vegetation. In: Power Lines and the Environment, Robert Goodland, Ed. Millbrook, N.Y.: The Cary Arboretum of the N.Y. Botanical Gardens. pp. 78-88.

Roach, J.F., V.L. Chartier, and F.M. Dietrich. 1973. Experimental oxidant production rates for EHV transmission lines and theoretical estimates of ozone concentrations near operating lines. IEEE Transaction Paper. T73-414-0.

Ross, Robert L., Earl P. Murray, and June G. Haigh. 1973. Soil and vegetation inventory of near-pristine sites: Montana. U.S.D.A., Soil Conservation Service, Bozeman, Mont. 62 pp.

Rouse, R.A. 1957. Elk food habits, range use, and movements, Gravelly Mountains, Montana. Unpublished thesis. Montana. State College, Bozeman.

Saunders, Jack K. 1955. Food habits and range use of the Rocky Mountain goat in the Crazy Mountains, Montana. J. of Wildl. Man. 19(4):429-37.

Schwarskoph, William Frederick. 1973. Range use and relationships of mule deer on the west slope of the Bridger Mountains, Montana. Unpublished Master's thesis. Montana State University, Bozeman.

Scott, Bruce I.H. 1962. Electricity in plants. Sci. Amer. 207 (4) :107-17.

Shearer, Raymond C., and Wyman C. Schmidt. 1965. Factors affecting seed potential. 2. Postdissemination losses of Ponderosa pine and Douglas fir seed. Proc. Mont. Acad. Sci. 29:85.

Scherer, H.N., Jr., B.J. Ware, and C.H. Shih. 1972. Gaseous effluents due to EHV transmission line corona. IEEE Transaction Paper. T72 550-2.

Smith, Darrel Wayne. 1969. A preliminary classification and characterization of big sagebrush, Artemisia tridentata, Nutt., communities in Central Montana. Unpublished thesis. Montana State University, Bozeman.

Smithsonian Institution. 1975. Report on endangered and threatened plant species of the United States of America. House Document No. 94-51. Serial No. 94-A. Washington, D.C. U.S. Government Printing Office. 200 pp.

Stahelin, R. 1943. Factors influencing the natural restocking of high altitude burns by coniferous trees in the central Rocky Mountains. Ecology 24(1):19-30.

Stickney, Peter F. 1974. SCS rare plant species listing for Montana. Unpublished mimeo. 7 pp.

Stickney, Peter F. 1960. Range of rough fescue (Festuca scabrella Torr.) in Montana. Proc. Mont. Acad. Sci. 20:12-17.

Taha, Faisal Khidir. 1972. The role of some environmental and man-made factors on big sagebrush (Artemisia tridentata) Nutt.) reinvasion. Unpublished thesis. Montana State University, Bozeman.

Treshow, M. 1965. Evaluation of vegetation injury as an air pollution criterion. J. Air. Poll. Cont. Asso. 15(6):266-67.

Treshow, Michael, and Dennis Stewart. 1973. Ozone sensitivity of plants in natural communities. Biol. Conserv. 5(3):209-214.

Turner, G.T., and G.E. Klipple. 1952. Growth characteristics of blue grama in northeastern Colorado. J. Range Man. 5622-28.

U. S. Bonneville Power Administration. 1972. Environment statement fiscal year 1973 proposed program. U.S. Dept. of Interior.

U S. Bonneville Power Administration. 1965. Brush control standard, Portland B.P.A., Transmission Standard No. 6341-1:31 pp.

U. S. Department of Agriculture, U.S. Forest Service. 1974. Deerlodge National Forest habitat types. 36 pp.

U. S. Department of Agriculture, U.S. Forest Service. 1973. Trees for polluted air. Mis. Publ., No. 1230. Wash., D.C. Government Printing Office.

Vogel, Willis G. 1960. A comparison of three range measurement techniques and a study of the response of native vegetation to protection from sheep grazing. Unpublished thesis. Montana State College, Bozeman.

Vogl, R.J. 1966. (Reply to Daubenmire 1966) Science 152:546.

Wagner, J. Frank. 1971. Make ecology work for you in ROW maintenance. Elect. Light and Power. 1971, September:72-3.

Walcheck, Kenneth C. 1969. Avian populations of four plant communities in the Bearpaw Mountains, Montana. Proc. Mont. Acad. Sci. 29:73-83.

Warner, R. 1970. Some aspects of browse production in relation to timber harvest methods and succession in western Montana. Unpublished thesis. Univ. of Montana, Missoula.

Weaver, T., and D. Dale. 1974. Pinus albicaulis in central Montana: environment, vegetation and production. Amer. Midl. Nat. 92(1):222-30.

White, Keith L. 1960. Differential range use by mule deer in the spruce-fir zone. Northwest Sci. 34(4):118-126.

Whitman, Warren C., H. Theo Hanson and Gordon Loder. 1943. Natural Revegetation of abandoned fields in western N. Dakota. N. Dakota Exper. Station Bull. No. 321., 18 pp.

Willard, B.E., and J.W. Marr. 1971 Recovery of alpine tundra under protection after damage by human activity in the Rocky Mountains of Colorado. Biol. Conserv. 3(3):131-190.

Willard, B.E., and J.W. Marr. 1970. Effects of human activities on alpine tundra ecosystems in Rocky Mountain National Park, Colorado. Biol. Conserv. 2(4):257-65.

Wright, John C., and Elnora A. Wright. 1948. Grassland types of south central Montana. Ecology 29(4):449-60.

Young, H.E. 1972. if you can't burn or spray, make it pay. Transmission and Distribution. 1972, (April):55-7.

Zhurbitskty, Z.I. 1972. Atmospheric electricity and plant nutrition problems. Translated from: Agrokhimiya 3:96-106.

Zuck, Robert K. 1973. Selective planting for the encouragement of wildlife. In: Power Lines and the environment, Robert Goodland, Ed. Millbrook, N.Y.: The Cary Arboretum of the New York Bot. Garden. p. 58-76.

BIBLIOGRAPHIES, REVIEW ARTICLES, AND BOOKS

Bogle, 1975. Microfische Bibliography on the effects of air pollutants on plants. EPA, Corvallis, Oregon.

Carpenter, L.H. and G.L. Williams. 1972. A literature review on the role of mineral fertilizers in big game range improvement. Colorado Div. of Game, Fish and Parks. Special Report No. 28.

Daubenmire, R. 1970. Steppe Vegetation of Washington. Wash. Agr. Exp. Stat. Tech. Bull. 62, 131 p.

Daubenmire, R. and Jean B. Daubenmire. 1968. Forest Vegetation of eastern Washington and northern Idaho. Washington Agricultural Experiment Station Tech. Bull. 60. 104 p.

Egler, F.E., 1973. Bibliography. Bridgewater, Connecticut. Connecticut Conservation Association. 8 p.

Ellison, Lincoln. 1960. Influence of grazing on plant succession of rangelands. Bot. Review 26 (1): 1-75.

Fowells, H.A. 1965. Silvics of forest trees of the U.S. U.S.D.A. Agric. Handbook 271, Doc. a.76, No. 271. 762 p.

Goodland, R. (Ed.) 1973. Power lines and the Environment. The Cary Arboretum of the New York Botanical Gardens, Millbrook, New York. 170 p.

Honkala, Rudolph A. 1974. Surface Mining and Mined Land Reclamation: A selected bibliography. The Old West Regional Commission, Washington, D.C. 154 p.

Hutnik, R.J. and G. Davis (Eds.). 1973. Ecology and reclamation of devastated land, Vol. I and II. Proceedings of a NATO advanced study institute on the ecology and revegetation of drastically disturbed areas. Held at the Penn. State Univ., Univ. Park, Pa., August 3-6, 1969. Vol. I: 538 p., Vol. II; 504 p.

Jameson, Donald A. 1963. Responses of individual plant to harvesting. Bot. Review 29:532-594.

Kitchings, J.T., H.H. Shugart and J.D. Story. 1974. Environmental impacts associated with electric transmission lines. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL-TM-4498. 100 p.

Kuchler, A.W. 1964. Manual to Accompany the Map, "Potential Natural Vegetation of the conterminous United States". American Geographical Society, Spec. Publ. No. 36. 116 p.

Liddle, M.J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. Biol. Conserv. 7:17-36.

Loomis, T.H.W. 1971. Compiled research data on reclamation of disturbed lands in the western U.S., 1970, BLM, USDI, Denver. Bibliography of research reports.

National Technical Information Service. 1974. NTIS research: Impact of transmission lines for the Energy Planning Division, Montana Department of Natural Resources. NTIS, U.S. Dept. Commerce, Springfield, Va.

Pfister, R.D., B.L. Kovalchik, S.F. Arno, and R.C. Presby. 1974. Forest habitat types of Montana. Northern Region, Intermountain Forest and Range Experiment Station, U.S.F.S., Missoula, Montana. 213 p.

Sheridan, Richard G. 1966. Bibliography on Montana's water and related land resources. Montana University Joint Water Resources Research Center Report #1. 80 p.

ADDITIONAL REFERENCES OF INTEREST

Appel, A.J. 1950. Possible soil restoration on "overgrazed" recreation areas. J.For. 48(5):368.

Albertson, F.W., D.A. Riegel, and G.W. Tomanek. 1966. Ecological studies of blue grama grass (Bouteloua gracilis). Fort Hays Stud., New Ser. Sci. Ser. No. 5. 37 p.

Blaisdell, J.P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River plains. U.S.D.A. Tech. Bull. No. 1075. 39 p.

Blaisdell, J.P. and W.F. Mueggler. 1956. Effect of 2,4-D on forbs and shrubs associated with big sagebrush. J. Range Man. 9:30-40.

Bleiweis, J.(ed.) 1966. Our Environment: How utilities protect it. Electrical World, 166(8): 61-78.

Booth, W.E. 1950. Flora of Montana. Pt. 1. Conifers and Monocots. Montana State College, Bozeman. 232 p.

Booth, W.E. and J.C. Wright. 1962. Flora of Montana. Pt. II. Dicotyledons. Montana State Coll., Bozeman. 280 p.

Bond, R. M. 1945. Range rodents and plant succession. North Amer. Wildlife Conf. Trans. 10:229-234.

Branson, Farrel A. and J.E. Weaver. 1953. Quantitative study of degeneration of mixed prairie. Bot. Gaz. 114:397-416.

Burden, R.F. and P.F. Randerson. 1972. Quantitative studies of the effects of human trampling on vegetation as an aid to the management of semi-natural areas. J. Appl. Ecol. 9:439-458.

Cook, C.W. and L.E. Harris. 1950. The nutritive value of range forage as affected by vegetation type, site, and state of maturity. Utah Agr. Exp. Sta. Bull. 344.

Cook, C.W. and C.E. Lewis. 1963. Competition between big sagebrush and seeded grasses on foothill ranges in Utah. J. Range Man. 16:245-250.

Cook, C.W., L.A. Stoddart and Lorin E. Harris. 1953. Effects of grazing intensity upon the nutritive value of range forage. J. Range Management 6:51-54.

Cooper, Harold W. 1953. Amounts of big sagebrush in plant communities near Tensleep, Wyoming, as influenced by grazing treatment. Ecology 34:186-189.

Cordell, Harold K. and D. R. Talhelm. 1969. Planting grass appears impractical for improving deteriorated recreation sites. S.E. Forest. Exp. Stn. Asheville, N.C. U.S.D.A. For. Serv. Res. Note SE-102, 2 p.

Costello, David. F. and George T. Turner. 1941. Vegetation changes following exclusion of livestock from grazed ranges. Jour. For. 39:310-315.

Culley, M.J., R.S. Campbell, and R.H. Canfield. 1933. Values and limitations of clipped quadrats. Ecology 14:35-39.

Dillon, C.C. 1967. Exposure may influence grassland establishment. J. Range Man. 20:69-72.

Dix, R.L. 1958. Some slope-plant relationships in the grasslands of the Little Missouri Badlands of North Dakota. J. Range Man. 11:88-92.

Edmond, D.B. 1966. The influence of animal treading on pasture growth. Int. Grassland Congr. 10:453-458.

Fautin, Reed W. 1946. Biotic communities of the northern desert shrub biome of western Utah. Ecol. Monog. 16:251-310.

Finzer, N. 1971. Timber cruise of Whitebark pine in the Wheeler Ridge area. U.S. Dept. of Agr., U.S. Forest Service, Gallatin Ranger District, Gallatin National Forest, Montana.

Gardner, J.L. 1950. Effects of thirty years of protection from grazing in desert grassland. Ecology 31:44-50.

Gashwiler, J.S. 1970. Plant and mammal changes on a clearcut in west-central Oregon. Ecology 51(6):1018-1026.

Georgia Power Company. 1973. Planting the right tree in the right place. Atlanta, Georgia. 16 p.

Goebel, Carl J. and C.W. Cook. 1960. Effect of range condition on plant vigor, production, and nutritive value of forage. J. Range Man. 13(6):307-313.

Hanson, H.C. and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecol. Monog. 8:57-114.

Harris, G.A. 1967. Some competitive relationships between _Agropyron spicatum_ and _Bromus tectorum_. Ecol. Monog. 37:89-111.

Heinselman, M.S. 1965. Vegetation management in wilderness areas and primitive parks. J. For. 63(6):440-445.

Hitchcock, C.L. _et al_. 1955-64. Vascular plants of the Pacific Northwest. Vols. 1, 2, 3, 4, 5. Univ. Wash. Press. Seattle.

Hughes, R.E. 1949. The classification of grassland plant communities and its relation to that of soil. Int. Grassland Congr., 5th Report: 154-160.

Hurd, Richard M. 1961. Grassland vegetation in the Bighorn Mountains, Wyoming. Ecology 42:459-467.

Johnson, W.M. 1958. Reinvasion of big sagebrush following chemical control. J. Range Man. 11:169-172.

Johnson, W.M. 1962. Vegetation of high altitude ranges in Wyoming as related to use by game and sheep. Laramie, Wyo., Univ. of Wyoming, Ag. Exp. Station. Bull. No. 387.

Joslyn, J.J. 1966. Christmas tree production on power line rights-of-way. Master's thesis, University of Massachusetts. 131 p.

Judd, B.I. 1940. Natural succession of vegetation on abandoned farm lands in Teton County, Montana. Jour. Amer. Soc. Agron. 32:330-336.

Ketchledge, E.H. 1971. Facility rehabilitation. P. 166-173, In: For. Recreation Symp. Proc. Northeast For. Exp. Stn., Upper Darby, Pa.

Klukas, R.W. and D.P. Duncan. 1967. Vegetational preferences among Itasca Park visitors. J. For. 65:18-21.

Larson, F. and W. Whitman. 1942. A comparison of used and unused grassland mesas in the badlands of South Dakota. Ecology 23:438-435.

Laude, H.M., A. Dadish, and R.M. Love. 1957. Differential effect of herbage removal on range species. J. Range Mangt. 10:116-120.

Leopold, Luna B., F.E. Clarke, B.B. Hanshaw, and J.R. Balsey. 1971. A procedure for evaluating environmental impact. Geological Survey Circular 645. Washington, D.C. 13 pp.

Liddle, M.J. 1973. The effects of trampling and vehicles on natural vegetation. Ph.D. thesis. Univ. College of North Wales, Bangor.

Logan, Norris. 1971. Chemical brush control: Assessing the hazards. J. Forest. :715-720.

MacConnel, W.P., D.L. Mader, and D.A. Oleksak. 1972. First christmas tree harvest on a power line right-of-way. American Christmas Tree J. 16:31-34.

Mackie, R.J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River breaks, Montana. Wild. Monog. 20. 79 p.

Marston, Richard B. 1952. Ground cover requirements for summer storm runoff control on aspen sites in northern Utah. J. For. 50:303-307.

Mueggler, W.F. 1971. Weather variations on a mountain grassland in southwestern Montana. U.S.D.A. Forest Service Res. Pap. INT-99,. 25 p.

Neff, Paul E. 1965. Applied silviculture in managing outdoor recreation sites. Soc. Am. For. Proc. 1965: 34-35.

Oosting, H.J. and J.F. Reed. 1952. Virgin spruce-fir forests in the Medicine Bow Mountains, Wyoming. Ecol. Monog. 22:69-91.

Packer, Paul E. 1953. Effects of trampling disturbance on watershed condition, runoff, and erosion. J. For. 51:28-31.

Quinnild, C.L. and H.B. Cosby. 1958. Relicts of climax vegetation on two mesas in western North Dakota. Ecology 39:29-32.

Rickard, W.H. 1964. Demise of sagebrush through soil changes. Bioscience 14:43-44.

Ripley, Thomas H. 1965. Rehabilitation of forest recreation sites. Soc. Am. For. Proc. 1965:35-36.

Short, L.R. and E.J. Woofolk. 1956. Plant vigor as a criterion of range condition. J. Range Man. 9:66-69.

Smith, D.R. 1960. Description and response to elk use of two mesic grassland and shrub communitites in the Jackson Hole region of Wyoming. Northwest Sci. 34:25-36.

Statler, R. 1966. An ecological study of a Rhode Island right-of-way. Unpublished Master's thesis, Botany Dept. University of Rhode Island, Kingston, R.I.

Stone, Edward C. 1965. Preserving vegetation in parks and wilderness. Sci. 150(3701):1261-1267.

Tackle, D. 1959. Silvics of Lodgepole pine. U.S.F.S. Int. For. and Range Expt. Sta., Misc. Pub. No. 19. 24 p.

Tanner, C.B. and C.P. Mamaril. 1959. Pasture compaction by animal traffic. Agron. J. 51:329-331.

U.S. Forest Service. 1966. Vegetation management for rights-of-way. U.S. Dept. of Agriculture, Forest Service, Eastern Region. 39 p.

Wagar, J.A. 1964. The carrying capacity of wildlands for recreation. Forest Sci. Monog. 7:1-24.

Way, J.M. 1969. Road verges, Research on management for amenity and wildlife. In: Road Verges, Their function and management, ed. by J.M. Way. 61-71. Abbots Ripton, Nature Conservancy.

Weaver, J.E. and R.W. Darland. 1947. A method of measuring vigor of range grasses. Ecology 28:146-162.

Westhoff, V. 1967. The ecological impact of pedestrian, equestrian, and vehicular traffic on vegetation. P.-v. Un. Int. Conserv. Nat. 10:218-223.

Wilson, H.K. 1944. Control of noxious plants. Bot. Rev. 10:279-326.

Worth, J.B., L.A. Ripperton, and C.R. Berry. 1967. Ozone variability in mountainous terrain. J. Geophys. Res. 72(8):2063-2068.

Young, L.B. 1973. Power over People. New York, Oxford University press, 216 p.